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Suitability of Fusing Vehicle Probe Data and Vessel Data to Contextualize the Multimodal Interaction Impacts on Corridor Mobility – a New Orleans Case Study

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Suitability of Fusing Vehicle Probe Data and Vessel Data to Contextualize the Multimodal
Interaction Impacts on Corridor Mobility – a New Orleans Case Study

A Thesis

Submitted to the Graduate Faculty of the
University of New Orleans
in partial fulfillment of the
requirements for the degree of

Master of Science
in
Transportation

by

Kirk Zeringue

B.S. Louisiana State University, 2000

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Table of Contents

List of Figures	iv
List of Tables	v
Acronyms	vi
Abstract	vii
Chapter 1: Introduction	1
Importance of Freight	1
Freight as a Causal Actor	2
Containers and Transportation System Interactions	4
Containers and the Panama Canal Expansion.....	5
Port Operations Interventions and Traffic Congestion	6
Port Competition and Traffic Congestion	7
Win-Win, Right?	9
Contribution of Thesis	10
Case Study	11
Chapter 2: Dataset Exploration and Characteristics	13
Vehicle Probe Data: National Performance Management Research Dataset	13
Vessel Probe Data: AIS	15
Alternative Vessel Data	18
USACE Entrances and Clearances	18
Port Websites	20
Container Data: PERS	20
Vehicle Traffic Data	21
DOTD-provided Traffic Volumes.....	22
DOTD Web-based Traffic Cameras	22
Chapter 3: Congestion Evaluation Method	24
Common Congestion Performance Metrics.....	24
Travel Time (TT)	25
Travel Time Index (TTI)	25
Buffer Index (BI).....	25
Planning Time Index (PTI)	25
MAP-21 Mobility Metrics	26

Level of Travel Time Reliability (LOTTR)	27
Truck Travel Time Reliability (TTTR)	27
Travel Time Cumulative Distribution Functions (CDF)	27
Chapter 4: Congestion Trend Analytics	30
Corridor Selection	30
Identifying Sub-corridors.....	33
Day Selection	35
Congested Period Identification.....	36
Impact of Container Vessel Presence.....	38
AIS-based Analysis	38
E&C-based Analysis	43
Impact of Container Vessel Size	47
E&C-based Analysis	47
Impact of Fluctuations in Container Truck/Chassis Traffic	51
Daily TEU-based Analysis.....	53
Weekly TEU-based Analysis.....	55
Impact of COB Intervention	56
Chapter 5: Implications for the Literature	64
Chapter 6: Conclusions and Future Work.....	70
Conclusions.....	70
Future Work	73
References	74
Appendix A. Hourly Traffic Volumes for October 2019.....	77
Appendix B. CDF plots Showing Impact of Container Vessel Presence for Each TMC Segment Based on AIS Data	79
Appendix C. CDF plots Showing Impact of Container Vessel Presence for Each TMC Segment Based on E&C Data	86
Appendix D. CDF plots Showing Impact of Container Vessel Size for Each TMC Segment Based on E&C Data	93
Vita	101

List of Figures

Figure 1. Illustration of trucks in the traffic stream [9]	4
Figure 2. Container terminal system (schematic side view, not true to size) [10]	4
Figure 3. Port NOLA container volumes (2014-2018).....	6
Figure 4. Vessel count calendar from AIS data	17
Figure 5. Vessel count calendar from E & C data.....	19
Figure 6. Daily TEU count during October 2019 for the Port of New Orleans.....	21
Figure 7. Container truck examples	23
Figure 8. Example CDF Scenarios	29
Figure 9. Map of study area (New Orleans).....	31
Figure 10. Map of DOTD cameras in New Orleans	32
Figure 11. Weekday (Mon - Thurs) average speeds of study corridor	33
Figure 12. Sub-corridor map	34
Figure 13. Section A speed profiles by day of the week.....	36
Figure 14. Sections A - F speed profiles showing congested periods.....	37
Figure 15. Location of sample TMC segments	39
Figure 16. Sample CDFs based on AIS for Section A-C.....	40
Figure 17. Sample CDFs based on AIS for Section D - F	40
Figure 18. Sample CDFs based on E&C data for Section A-C	43
Figure 19. Sample CDFs based on E&C data for Section D-F	44
Figure 20. Combined vessel count calendar from AIS and E&C data	46
Figure 21. Sample CDFs based on E&C dimension data for Section A-C	49
Figure 22. Sample CDFs based on E&C dimension data for Section D-F	50
Figure 23. CDF plots based on weekday travel times grouped by TEU Count.....	52
Figure 24. CDF plots based on weekday travel times grouped by week	52
Figure 25. IQR for weekday TEU counts in October 2019 at the Port NOLA	53
Figure 26. AM peak period daily traffic volumes by TEU range on section A-3	54
Figure 27. Weekly TEU totals in October 2019 at the Port of New Orleans.....	56
Figure 28. Example ITA plot	58
Figure 29. ITA plots of sample TMC segments from sections A - C	61
Figure 30. ITA plots of sample TMC segments from sections D - F	62
Figure 31. January 2016 - May 2017 traffic volumes on I-10	63
Figure 32. Example view of from DOTD traffic camera on I-10 at Williams Blvd.	65
Figure 33. NRT vs. TEUs for October 2019	68

List of Tables

Table 1. Corridor Details	35
Table 2. Cumulative NRT Ranges and Count of Travel Time Observations	48
Table 3. Sample of Container Truck Traffic on Sub-corridor A	66

Acronyms

AIS	Automatic Identification System
AISAP	Automatic Identification System Analysis Package
AOI	Area of Interest
BI	Buffer Index
BTS	Bureau of Transportation Statistics
COB	Container on Barge
CT	Combination Trucks
CV	Container Vehicle
CDF	Cumulative Distribution Functions
DOT	Department of Transportation
DOTD	Department of Transportation and Development
ERDC	Engineer Research and Development Center
E&C	Entrances and Clearances
FAST	Fixing America's Surface Transportation
FFTT	Free Flow Travel Time
FHWA	Federal Highway Administration
GPS	Global Positioning System
HCM	Highway Capacity Manual
ITA	Innovative Trend Analysis
LOTTR	Level of Travel Time Reliability
MAP-21	Moving Ahead for Progress in the 21st Century
MPO	Metropolitan Planning Organization
NAIS	Nationwide AIS
NCST	National Center for Sustainable Transportation
NHS	National Highway System
NPMRDS	National Performance Management Research Data Set
NRT	Net Registered Tonnage
PANYNJ	Port Authority of New York and New Jersey
PCE	Panama Canal Expansion
PIERS	Port Import/Export Reporting Service
Port	NOLA Port of New Orleans
PTI	Planning Time Index
TEU	Twenty-foot Equivalent Unit
TMC	Traffic Message Channel
TPM	Transportation Performance Management
TTI	Travel Time Index
TTTR	Truck Travel Time Reliability
US	United States
USACE	United State Army Corps of Engineers
USCG	United States Coast Guard
USDOT	United States Department of Transportation
VMT	Vehicle Miles Travelled

Abstract

Using New Orleans as a case study, this thesis explores the conflation of vehicle probe data with various vessel datasets to characterize the interactions between container vessels and motor vehicles as it relates to interstate congestion in a port city. The case study investigates the impact of container vessel presence/size, fluctuations in container volumes, and container on barge services on roadway congestion. The exploration relies on comparing different conditions using cumulative distribution functions and the Innovative Trend Analysis. The results showed that fusing vehicle and vessel data is achievable and appropriate, but temporal and data completeness issues can effect results. The results also showed that by joining these modally disparate datasets together and analyzing them as one, additional context is added to discussions related to transportation operations and investment decision-making through either the confirmation or disproval of perceptions or expected results related to container truck traffic on an interstate.

Keywords: NPMRDS; AIS; congestion; containers; trucks; COB

Chapter 1: Introduction

The amount of traffic congestion in the United States' (US) metropolitan areas is a recurring and growing concern among the operators and users of the transportation system. The increasing congestion trends are documented by the Federal Highway Administration's (FHWA) Urban Mobility Report, which shows an overall increase in congestion (measured by total hours of delay) in urban areas of 14%, or 1.1 billion hours, over the 5-year period ending in 2017 [1]. The trend is similar when examining the same data for Louisiana's two largest metropolitan areas. In New Orleans and Baton Rouge, the annual hours of delay has increased 11% and 16%, respectively, from 2013 to 2017.

The increases in congestion are the result of many contributing factors including, but not limited to, growth in demand for both passenger travel and freight travel. Although trucks only account for 7% of urban travel in the US, truck vehicle miles travelled (VMT) has increased faster than passenger VMT. Nationally, passenger VMT and freight VMT have increased 9.8% and 11.4%, respectively, from 2013 to 2017 [2]. That trend is projected to continue over the next 30 years [3]. The result of that trend is an ever-increasing proportion of freight-carrying trucks in the traffic stream.

Importance of Freight

The movement of freight is essential to the economy of the United States. The makeup of truck traffic includes both trucks that pick up or drop off cargo within the region or state and trucks that are simply passing through. In Louisiana, trucks carry over 44% of the freight by weight and over 41% of the freight by value [4]. Pass-through traffic makes up 41% (13.6 billion)

of the freight ton miles traveled in Louisiana [5]. This means that about 59% of truck traffic either originates or terminates within the state. In the case of container trucks, this origination or termination point is usually at a port facility. Since the economic benefits of pass-through truck traffic are minimal (perhaps stopping for food and fuel) and the external costs affiliated with them (e.g. congestion, pollution, noise, and increased roadway maintenance) are substantial, pass-through truck traffic is usually perceived by states/regions as negative [5]. However, while port-related traffic results in the same substantial external costs, it is widely accepted that ports provide significant economic benefits to a region or state.

Freight as a Causal Actor

When discussing freight-related congestion, the conventional practice has been to assess the impact that overall congestion has on the movement of freight. While that type of assessment is informative and will continue in practice, the Fixing America's Surface Transportation (FAST) Act has added an emphasis on the reciprocal perspective - *what are the impacts to congestion caused by freight* [6]? Researchers in France explored this idea of reciprocal congestion (freight as the causal actor) in the Paris region and found that one additional percent of trucks within the traffic stream has a much bigger impact (increase by 30 minutes) on congestion than one additional percent of passenger vehicles (increase by 10 minutes) [7].

Recognizing that there had been no previous studies treating freight as the causal agent for congestion, the National Center for Sustainable Transportation (NCST) developed a methodology to identify freight impact areas for the California Department of Transportation

(Caltrans) [8]. The NCST defines a freight impact area as a "severely congested roadway corridor with high volumes of trucks." The NCST methodology for identifying freight impact areas relies on the calculation of a peak hour freight congestion value (PHFCV) for each roadway segment and compares it to the rest of the segments within the region or state to identify the top 15 freight impact areas. Vehicle probe data from FHWA's National Performance Management Research Data Set (NPMRDS) was explored as a potential dataset in the NCST study, but was found to be inadequate for their purposes primarily due to the lack of associated volume information. Worth noting is that those NPMRDS limitations have now been overcome by conflation with FHWA's Highway Performance Monitoring System data in the second version of the NPMRDS starting in 2016. Ultimately, the NCST team relied on simulation model data to inform their analysis.

The relationship between increased truck traffic and its effect on congestion was also investigated by using vehicle trajectory data on I-80 in California [9]. Moridpour et. al. (2015) found that during heavy traffic conditions (Level of Service E¹), the average travel times of all vehicles (i.e. passenger cars, truck, buses, etc.) increases when the proportion of heavy vehicles (trucks) rises in each lane. They also concluded that in addition to their physical effects (longer vehicle lengths), trucks cause psychological effects on surrounding drivers (left, right, front, rear) resulting in the front and rear spacing gaps being larger for trucks than that of passenger cars as illustrated in Figure 1 below. In addition, they found that there is a 5% increase in the likelihood of accidents when the percentage of trucks in the traffic stream reaches or exceeds 30%.

¹ Unstable flow at or near capacity levels with poor levels of comfort and convenience

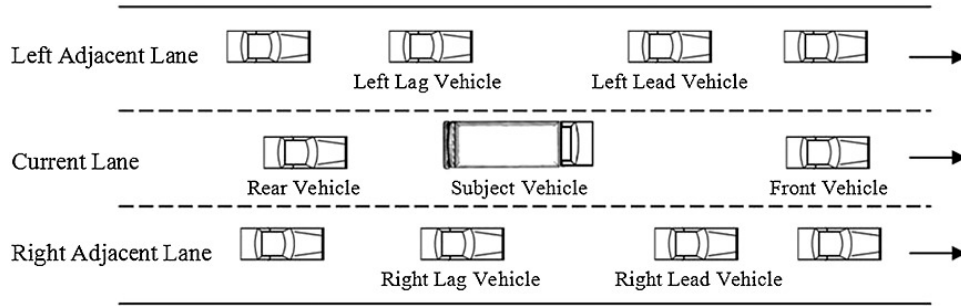


Figure 1. Illustration of trucks in the traffic stream [9]

Containers and Transportation System Interactions

Containers attract most of the attention when considering the impacts of port-related traffic on highway congestion perhaps because of the easily identifiable appearance of shipping containers. The motoring public interacts directly with trucked shipping containers on the road on a daily basis. However, trucking is not the only mode by which containers interact with the transportation system. Figure 2 illustrates a typical container terminal system showing that the landside transport of containers can occur by either truck or train.

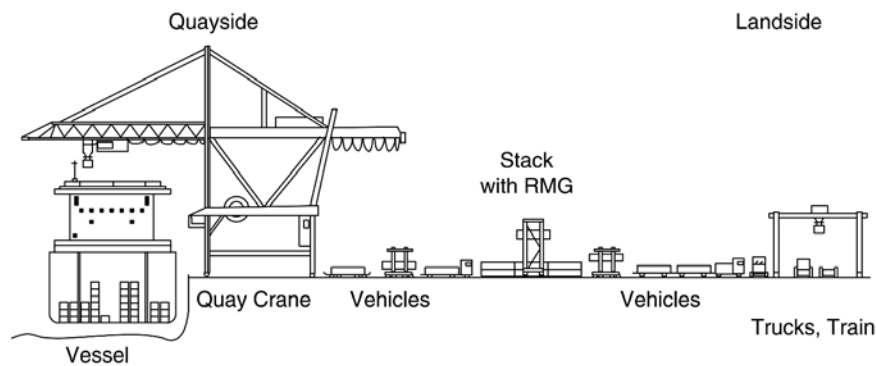


Figure 2. Container terminal system (schematic side view, not true to size) [10]

What is not shown in Figure 2 is the option of transporting containers on barge (COB). The COB transport option allows containers movements farther inland by water to parts that are unreachable by deep draft ocean going vessels. Increasingly, containers on rail and/or COB are

often pointed to as means to minimize the number of container trucks on highways. Both modes are present in Louisiana with containers making up about 4.9% of the inbound rail tonnage and 4.5% of the outbound rail tonnage in 2015 [11]. Since its return to Louisiana in 2016, the Port of Greater Baton Rouge has handled 8,018 containers in 2017 and 13,685 containers in 2018 [12]. When compared to the tonnage of containers moved by truck in Louisiana at 55.2 million tons in 2012, the tonnage of containers moved by rail (4.8 million tons) pales in comparison [4].

Containers and the Panama Canal Expansion

Containers attract most of the attention when considering the impacts of port-related traffic on highway congestion perhaps because of the easily identifiable appearance of shipping containers. At the Port of Durban, researchers conducted a quantitative study to determine the impact of port-related traffic on the city's road network and found that container truck traffic is the largest overall contributor to truck volumes on its roadways [13]. This finding is not surprising in major deep draft port cities and with the completion of the Panama Canal Expansion (PCE) in 2016, it is expected to be even more prevalent in those port cities that have at least 50 feet of depth available and can, thus, receive even larger post-Panamax vessels².

In an effort to understand and quantify the effect of post-Panamax vessels on the highway system, the Port Authority of New York and New Jersey (PANYNJ) conducted a study that used Global Positioning System (GPS) data to ultimately develop a simulation model that evaluates at what point container traffic growth results in queuing that spills over from the local roadway network to the highway network in the vicinity of the PANYNJ [14]. Other similar simulation-

² Post-Panamax refers to the vessels who couldn't fit through the Panama Canal lock prior to the PCE, but now may be able to.

based approaches to evaluating the effect of container traffic on the local roads immediately surrounding ports have been conducted including one for the Port of Savannah [15] [16].

The most recent data available from the United States Department of Transportation's (USDOT) Bureau of Transportation Statistics (BTS) for the Port of New Orleans (Port NOLA) reveals that they are just beginning to see increases in twenty-foot equivalent units (TEU) since the PCE's completion [17]. Figure 3 shows a modest growth from 2016 to 2017 of 0.7

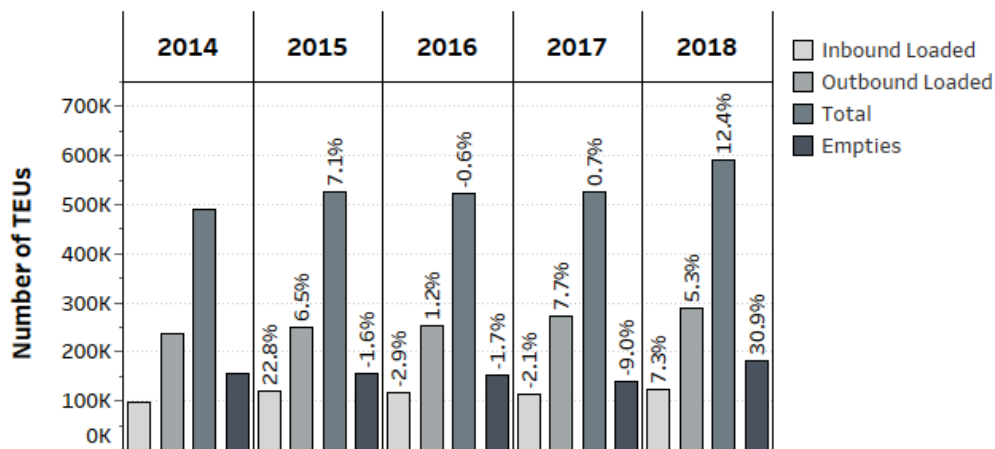


Figure 3. Port NOLA container volumes (2014-2018)

Port Operations Interventions and Traffic Congestion

Turnaround times for container trucks in a terminal is considered to be one of the most important performance measures for port operations [18]. The three basic truck-related factors that should be considered when evaluating turnaround times are the traffic conditions approaching the port, the availability of trucks, and the capacity of trucks [19]. A fourth factor, not specifically mentioned in the report, but perhaps as important as any of the other three is the availability of chassis. For container port systems, the goal of traffic planning should not just focus on the flow of truck through terminal gates, it must be about finding synergies between

ports and cities/regions and the recognition that while ports are vital to urban economies, they should not be considered monopolistic, and thus, should not seek to address traffic planning challenges alone [20]. This type of synergy is evident in the initiative to move containers on barge (COB) between Port NOLA, the Port of Greater Baton Rouge, and the Port of Memphis. The initiative began in 2016 with the idea of this COB service as a means to mitigate increased congestion due to increased container traffic through the Port Nola by keeping the increased demand off of the highways and on the water to a point further inland. While the return of COB service is relatively new to Louisiana, that same type of synergy has long existed at the Port of New Orleans with its intermodal connection capabilities that allow container on rail service to originate and terminate at the Port.

Another example of interventions in port operations that can have an impact on interstate congestion is the utilization of a truck appointment system. This type of system ensures an even flow of trucks to and from the port and prevents the port and surrounding roadways from being overwhelmed by too many vehicles at one time (e.g. when the gates open in the morning). A truck scheduling system is in place at Port NOLA where each container terminal operator (there are two) typically allows 110 appointments per hour and averages about 850 gate moves a day per terminal [21].

Port Competition and Traffic Congestion

Since roads play a vital role in the movement of goods, they also play a role in port competition for business. Roads are an essential part of the intermodal chain and when they are congested, can reduce a port's competitiveness with other ports [22]. A quantity-based analysis

of the interaction between urban road congestion and port competition among ports from different regions (supply chains) showed that an increase in road capacity for one intermodal chain would likely benefit the port being served, but also negatively impact the rival port [23]. Therefore, when an agency such as the Louisiana Department of Transportation & Development (DOTD) needs to make an investment decision on which roadway capacity projects to fund, it must be cognizant of the effect it may have on competing ports within the state. At present, Louisiana's only major container port within the state is the Port of New Orleans (ranked #17 in total TEUs in the US in 2018), but Louisiana does have competing container ports at the regional level with Gulfport (#24) and Mobile (#20) and at the megaregion level with Houston (#5) [17]. In the same vein, when ports and other state agencies are making port related infrastructure and operations funding decisions, it should be equally cognizant of the impact that funding decision may have on roadway congestion.

This perspective makes a case for a state department of transportation (DOT) to invest in projects that reduce congestion for the benefit of port-related economic development in their own state. However, an opposing perspective is that port-related freight traffic contributes to urban congestion and, thus, ports and state agencies should be equally cognizant of the effect its investments may have on roadway congestion. To illustrate that point, a study of the Port of New York found that a modest increase (6.4%) in container traffic would result in annual "social costs" of up to \$1.62 billion dollars, with over 60% of that increase coming from road congestion user delay costs [24].

Win-Win, Right?

From either perspective, one might appropriately suggest that a state DOT's investment in mitigating roadway congestion is a win-win for both ports and roadway users. However, that suggestion only holds true in an environment where state DOTs have unlimited funds for congestion mitigation projects. The reality is that state DOTs' needs far exceed available funding sources. According to the 2017 Louisiana DOTD Needs Assessment, Louisiana has a backlog of over \$10.6 billion of roadway needs along with an additional \$3.5 billion of bridge needs, while only having about \$900 million of available funding per year [25].

Adding to this needs/funds dichotomy is the structure of ports within in a state. In Louisiana, ports are created by the state legislature as political subdivisions of the state. The fact that they are each effectively state agencies results in a climate where Louisiana's six deep draft ports are in competition with each other for limited state funds (e.g. Capital outlay³, LED⁴, DOTD⁵, etc.). With the expansion of the Panama Canal, and the potential associated growth in container traffic, ports in Louisiana have announced plans for either expanding existing container terminal capacity (Port Nola) or building new terminals at new sites (Port Nola, St. Bernard Port, and Plaquemines Port).

³ Capital Outlay funds are for projects other than those funded from self-generated cash, federal funds, or dedicated revenues, whose only anticipated source of funding available is the sale of general obligation bonds (source: <https://www.doa.la.gov/Pages/ofpc/Capital%20Outlay/QualificationsforInclusion.aspx>)

⁴ LED, or Louisiana Economic Development, is a state agency with the goal of strengthening the state's business environment and creating a more vibrant Louisiana economy with several funding opportunities for business (source: <https://www.opportunitylouisiana.com/>)

⁵ Louisiana DOTD has fuel tax-based federal and state funds available for projects. In addition, the LA Legislature established the Port Priority Program (funded by state dollars) in 1989 in which ports compete for available funds. (source: http://wwwsp.dotd.la.gov/inside_ladotd/divisions/multimodal/port_priority/pages/ports.aspx)

The competition for limited funds in the state creates an environment where a state agency, such as the Louisiana DOTD, can't meet the roadway infrastructure needs of all ports, and thus, must effectively choose winners and losers. Transportation programming and investment decision making for state DOTs usually involves many factors that are guided by goals, performance measures, and data that ultimately weigh the benefits and costs of given investment alternatives. One common factor is the effect a project will have on mobility of all users.

In the case of the Louisiana DOTD, with its various roadway project funding pots along with its port infrastructure-related funding pot (the Port Priority Program), it is in a position to be the funding agency for both perspectives whereas its decision to fund a port project could have an adverse effect on roadway congestion and its decision to fund a road project could have an adverse effect on a competing port. This truly multimodal responsibility is the type of consideration that the FAST Act is emphasizing. In order to judiciously weigh these competing perspectives, agencies like the Louisiana DOTD must be able to draw from analyses of available data sources in order to make the most informed investment decisions

Contribution of Thesis

A common theme throughout the literature reviewed for this study is this premise that increases in quantity and frequency of traffic on the quayside (waterside) result in increased traffic and congestion on the landside (highways). More specifically, the literature suggests that there are widespread underlying assumptions and beliefs that increases in the size/capacity of cargo vessels and increases in the frequency of port calls of cargo vessels has an adverse

(increasing) effect on roadway congestion in a given port city or region. The conventional practice appears to have relied on hypothetical simulation models to quantify that relationship which then informs the narrative and ultimately results in the narrative/assumptions being built back into subsequent models. The contribution of this thesis is twofold: (1) to determine whether real-world data can be used to validate those assumptions and (2) to determine if the assumptions are valid in a given port city.

By exploring the interaction between interstate mobility and port-related freight travel (specifically, container traffic), the methodologies employed in this thesis and the resulting context gained could then be used to improve existing simulation models or inform new ones. In addition, this added context can be a key factor in assessing the impacts of previous transportation investment decisions or in informing future ones.

Case Study

Mobility affects everyone and case studies are particularly useful in research whose results benefit the public good [26]. Since the literature review revealed that the fusion of vessel and vehicle probe data has not been comprehensively studied, a case study approach was employed to facilitate the exploration. The advantage of utilizing a case study approach is that it affords the best opportunity to identify relationships between the ideas explored in this thesis and the real-world impact of those relationships.

To explore the idea that vessels and their cargo can have a direct impact on interstate congestion in the metropolitan region surrounding a port, this thesis used the New Orleans, LA region and its associated container cargo movements (in and out) for its case study. The case

study relies on data from continuous observations of real vehicle activity and real vessel movements in the form of vehicle probe data and publicly available vessel data of varying temporal granularities. The datasets used in the case study are archived real-world data covering 2016 – 2018 and October 2019. Specifically, the case study conflates activity data from vessel traffic at Port NOLA with activity data from vehicle traffic on I-10 in Jefferson and Orleans Parishes (from NPMRDS) to determine if that conflation can be analyzed in a way that either validates or invalidates the aforementioned assumptions. To accomplish this, the case study poses the following three questions:

1. What is the impact of container vessel presence and size on interstate congestion on a corridor?
2. What is the impact of daily fluctuations in port container volumes on a corridor?
3. What is the impact of an operational intervention, COB, on congestion in a corridor?

Chapter 2: Dataset Exploration and Characteristics

Several sources of data were considered for inclusion in this study, but in order to answer the questions posed by this thesis, only datasets that included physical, temporal, and spatial accounting were ultimately included in the analysis. That is, the data needed to include a field that described a physical trait of the vehicle or vessel (e.g. dimensions, classification, capacity, etc.) being analyzed. The data needed to also have a field(s) that describe when those vehicles or vessels movements through the study area (New Orleans) occurred. Finally, the dataset must include location information that described the geospatial positioning of the vehicles or vessels in order to associate their movements (temporally) with one another.

Vehicle Probe Data: National Performance Management Research Dataset

The NPMRDS is an initiative funded by FHWA to provide state DOTs and Metropolitan Planning Organizations (MPO) the necessary data to meet the performance management target setting and reporting requirements mandated under the 2012 Moving Ahead for Progress in the 21st Century (MAP-21) and the 2015 FAST Act federal legislations. Access to the data is provided to state DOTs and MPOs through an online tool provided by FHWA through its contractor – the Center for Advanced Transportation Technology Laboratory at the University of Maryland⁶. Specifically, the NPMRDS is vehicle probe-based data set that provides historic travel times and speeds for trucks and passenger cars on a segment basis for the entire National Highway System (NHS). Each segment is referred to as a traffic message channel (TMC) in the NPMRDS. The data is collected for each TMC segment and is provided in 5-minute increments (epochs) for each hour

⁶ <https://npmrds.ritis.org/analytics/>

of every day since 2011 [27]. There are 47 data element available as part of the two-file dataset. One file represents the collected probe data (7 fields) and the other file represents the roadway segment attributes data (40 fields). The data fields utilized in this thesis are described below.

- *tmc_code* or *tmc* is the unique 9-digit value identifying the TMC segment
- *measurement_timestamp* is the date of the data record, in “MM/DD/YY HH:NN:SS A” format (local time)
- *speed* is the harmonic average speed for all reporting vehicles on the segment, recorded in mph as an integer
- *reference_speed* is the calculated "free flow" mean speed for the roadway segment in miles per hour (calculated based upon the 85th-percentile point of the observed speeds on that segment for all time periods, which establishes a reliable proxy for the speed of traffic at free-flow for that segment)
- *travel_time_seconds* or *travel_time_minutes* is the travel time recorded in seconds or minutes (calculated as the ratio between the segment length and the harmonic average speed for all reporting vehicles on the segment)
- *miles* is the length of the TMC segment along the road in miles
- *road_order* is a numerical value indicating in what order the TMC segment would be encountered when traveling downstream relative to the other TMC segments on the same road
- *data-density* refers to one of three values representing the number of speed observations for a given TMC segment during that 5-minute period of time ('A' is fewer than five values, 'B' is five to nine values, and 'C' is more than nine values)

Vessel Probe Data: AIS

According to the United States Coast Guard (USCG), the Automatic Identification System (AIS) is a maritime navigation safety communications system that provides vessel information (i.e. vessel's identity, type, position, course, speed, navigational status, and other safety-related information) automatically to appropriately equipped shore stations, other ships, and aircraft. The AIS system automatically receives information from similarly fitted ships, monitors/tracks ships, and exchanges data with shore-based facilities. Local, state and federal government agencies can request real-time or historical USCG Nationwide AIS (NAIS) data through the USCG's NAIS Data Request website [28].

Another way to access AIS data is through the United State Army Corps of Engineers (USACE) Automatic Identification System Analysis Package (AISAP) which is a “web-based tool for acquiring, analyzing, and visualizing real-time and archival data from the U.S. Coastal Guard. Archived AIS data include location, time, speed-over-ground, direction, vessel draft, beam, length, and vessel type information. Through AISAP, USACE personnel can define spatial and temporal filters, visualize traffic density patterns, and analyze vessel utilization patterns [29].”

The AISAP tool only gives access to three previous years of data from the current date. Since the period being analyzed in this study (2016 – 2018) includes significant periods of time outside of the last three years, accessing all the data directly from the tool was not an option. Therefore, the USACE Engineer Research and Development Center (ERDC) provided the three years of AIS data for the Port NOLA directly via a Microsoft Excel file. Ultimately, only four of the provided data fields were used in this study and are described below.

- *Vessel Name* contains the name of the vessel

- *ECType ICST_Desc* identifies the type of vessel (e.g. container)
- *Start Time* is the date and time (in 5-minute increments) the vessel entered the area of interest
- *Stop Time* is the date and time the vessel exited the area of interest

Two other fields, *Length (ft.)* and *Width (ft.)*, were also considered for use in the analysis. However, after exploring the data further, it became apparent that these fields were not necessarily accurate in all cases so they were ultimately not used in the analysis. A more detailed discussion of this exclusion is provided in Chapter 4.

The AIS data, in calendar form, is shown in Figure 4. The raw data is available upon request. Each 5-minute time period is shaded to represent the number of vessels in port at that time. The lightest gray represents when no vessels are in port and the darkest gray represents when four or more vessels are in port. Also included in the figure is the number of 5-minute periods associated with each vessel count condition.

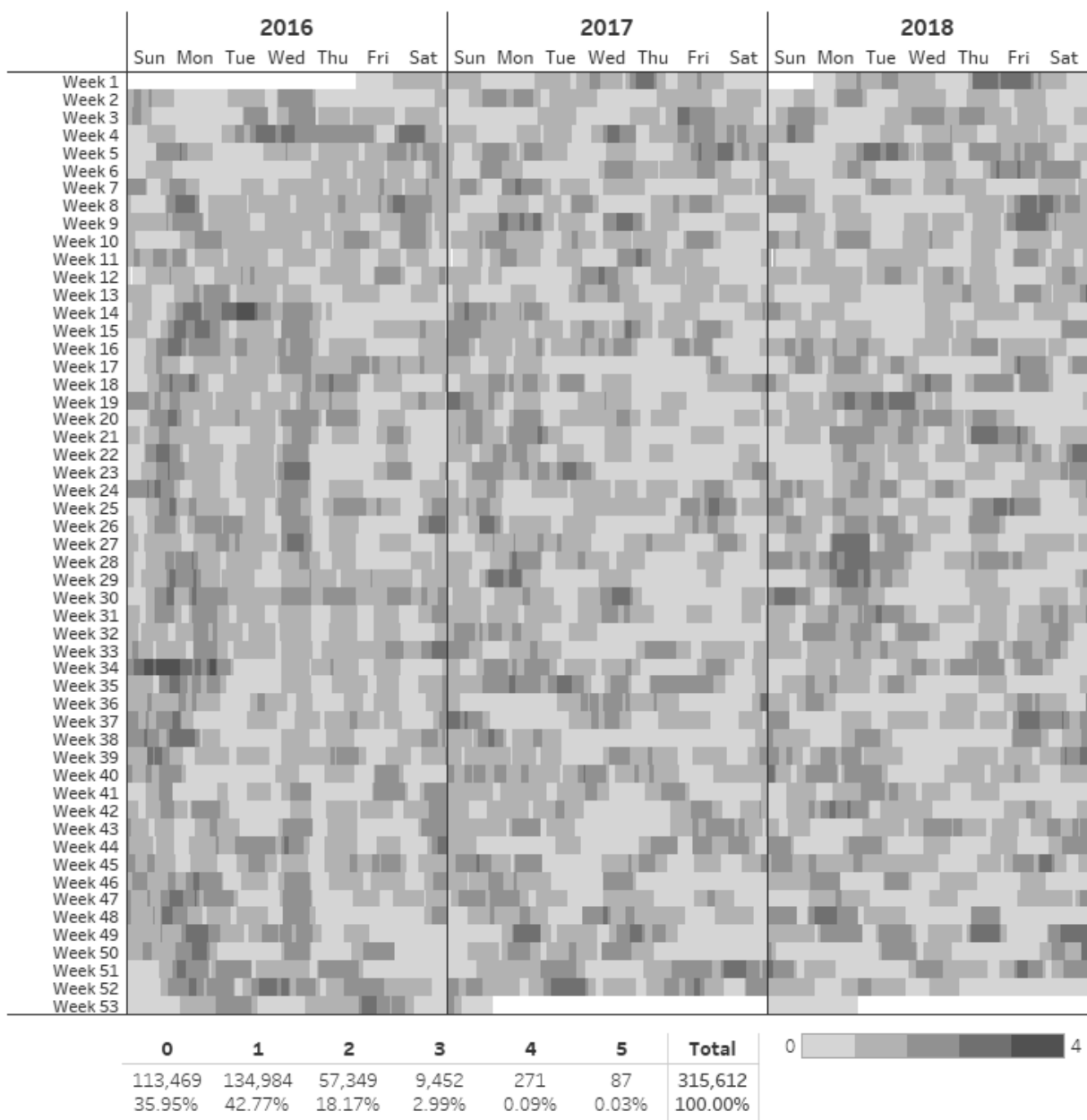


Figure 4. Vessel count calendar from AIS data

Alternative Vessel Data

USACE Entrances and Clearances

The USACE publishes annually its Foreign Traffic Vessel Entrances and Clearances (E&C) data which documents the date each vessel enters and leaves a port and provides vessel-specific information as well. The USACE publishes a data dictionary can that provides a full description of each of the available data fields [30]. Only six of the available data fields were used in this study and are described below.

- *TYPEDOC* is a one digit code identifying the type of document (record). A "0" indicates vessel *entrance* record and a "1" indicates a vessel *clearance* record.
- *ECDATE* is the date a vessel made entry into (*entrance* record) or cleared (*clearance* record) the U.S. Customs port. The five character date format is MonthYearDay where Month is 01 to 12, Year is the last digit of the year, and Day is 01 to 31.
- *PORT_NAME* contains the description for the U.S. port that a vessel has entered or cleared. In this study, only records with the "PORT OF NEW ORLEANS, LA" value was used.
- *VESSNAME* contains the vessel's full name up to 36 characters.
- *NRT* contains the net registered tonnage of the vessel. Despite the name of the field, in this case the "tonnage" is not a weight measurement. It is, in fact, a volume measurement intended to represent the volume of available revenue earning space on a given vessel. NRT, along with GRT (gross registered tonnage), are primarily used as the basis for vessel regulation and assessment of taxes and fees [31].

- *CONTAINER* indicates whether the vessel carries containers ("C") or not (blank). Only vessels carrying containers were included in this study.

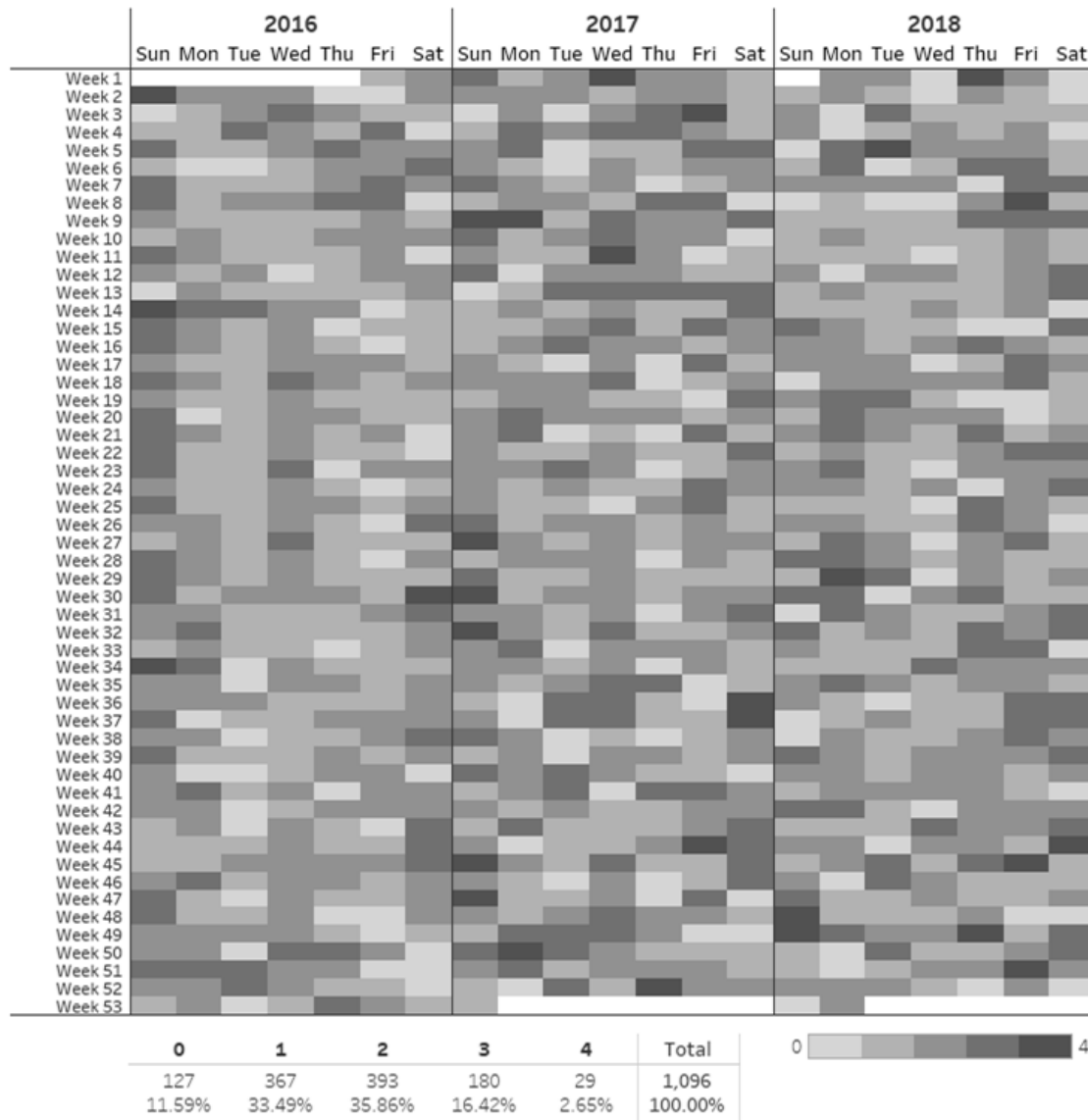


Figure 5. Vessel count calendar from E & C data

The *entrance* records and the *clearance* records are published in the same Excel file but in separate tabs. In order to facilitate the analysis required for this thesis, the each individual *clearance* record was associated with its apparent partner *entrance* record. The result of that exercise is shown in calendar form in Figure 5. Each day is shaded to represent the number of

vessels in port that day. The lightest gray represents when no vessels are in port and the darkest gray represents when four or more vessels are in port. Also included in the figure is the number of days associated with each vessel count condition.

Port Websites

In some cases, vessel data can be obtained directly from port websites. This is the case for Port NOLA where the arrival and departure schedules for the next 30 days are provided on their public facing website⁷. The schedules can be viewed separately for container, breakbulk, and cruise vessels. Since this data is for upcoming vessel calls, its use for historical analysis is limited. However, it could be useful in coordinating future data collection activities to ensure and log the presence of vessels during those data collection windows.

Container Data: PIERS

The Port Import/Export Reporting Service (PIERS) collects data from the Bill of Lading for all waterborne cargo vessels that enter or exit any port in the US. This bill of lading data is analyzed and fused with complementary datasets to produce what is commonly referred to as PIERS data. PIERS data is acquired through a subscription-based private service from IHS Markit, Inc. PIERS data is typically used for market share and trend analysis by various industries and government agencies.

Among the many data elements included in PIERS, is a simple date-stamped account of each container that enters or exits a given port along with the vessel on which it arrived or

⁷ <https://portno.force.com/mvp/s/>

departed. For the purposes of this thesis, that information is valuable in analyzing how fluctuations in container traffic at a port might influence congestion on a given roadway.

A one month sample of the data was provided by IHS Markit, Inc. for limited use in this thesis. The fields that were provided included the date, vessel name, direction (E-export, or I-import), and the twenty-foot equivalent unit (TEU) count for the month of October 2019 at Port NOLA. Figure 6 shows a daily summary of the data which reveals that there are fluctuations in the daily TEU count handled by the Port. This data is proprietary and confidential and the property of IHS Markit Inc. It must not be copied, stored or replicated in any form without the prior permission of IHS Markit Inc.

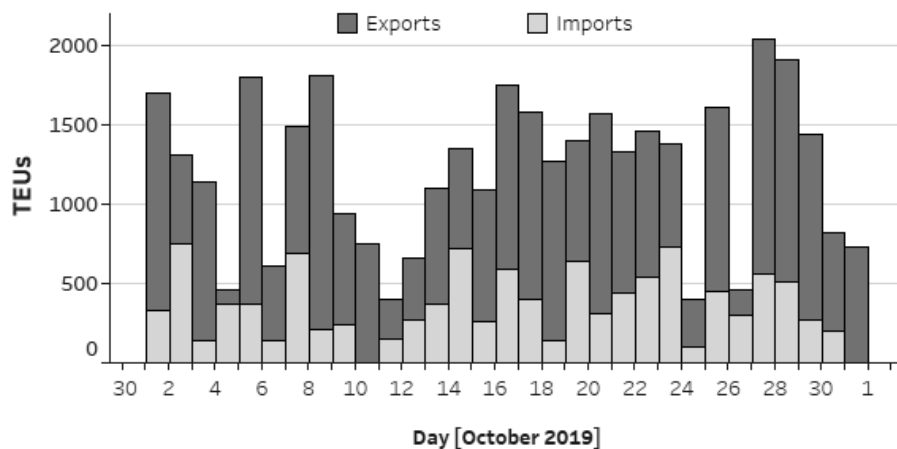


Figure 6. Daily TEU count during October 2019 for the Port of New Orleans

Vehicle Traffic Data

Vehicle traffic data can provide additional context to the analyses when considering the effects that variations in traffic volumes can have on congestion. For the portions of the case study that use larger temporal data sets (questions 1 and 3 in the case study scope), the effects

of daily fluctuations in vehicle traffic volumes tend to be minimized due to the overall smoothing of the data that naturally occurs with the larger data set. However, when only conducting a daily analysis based on one month of data (as in question 2), the effect of those daily traffic volume fluctuations can play a major role in the characterization of congestion for a given day. There were two sources of vehicle traffic data identified for used in this study: (1) DOTD-provided hourly volumes for the month of October 2019; and (2) DOTD's web-based traffic cameras. Each source is described in more detail below.

DOTD-provided Traffic Volumes

DOTD has what is referred to as permanent count stations located throughout the state on various functional classifications of roadways. One of those permanent count stations is located on I-10 within the corridor that was ultimately selected for this case study. In addition to hourly traffic volumes by direction of travel, the equipment deployed at this particular permanent count station also has the ability to collect vehicle classification counts (i.e. percentage of passenger cars, single unit trucks, and combination trucks). The October 2019 dataset used in this thesis can be found in Appendix A.

DOTD Web-based Traffic Cameras

DOTD has also deployed traffic cameras throughout the state in order to aid in real-time traffic operations. As a service to the public, these cameras can be accessed by anyone through DOTD's website. DOTD does not record or archive these video feeds, but since they are streamed on DOTD's public-facing website, the URL feed can be recorded using video capture software. These traffic camera feeds can be useful for data collection purposes. For this thesis, traffic

cameras provided a way to collect container-specific volume information, which can then be compared with the DOTD-provided overall traffic volumes. There are four container vehicle (CV) types that can be identified in the video feeds:

- A. Trucks hauling small containers (one or less TEU)
- B. Trucks hauling large containers (more than one TEU)
- C. Trucks hauling chassis (no container)
- D. Trucks hauling tank-tainers

An example of these four vehicle types as captured by a traffic camera is shown in Figure 7.



Figure 7. Container truck examples

Chapter 3: Congestion Evaluation Method

As a basis for the analyses conducted in this thesis, it is important to select an appropriate method to evaluate the mobility measures that characterize congestion. Mobility measures can be categorized into 2 groups: individual measures and area mobility measures [32]. Individual measures are those that apply to the individual traveler and area measures are more applicable beyond the individual. Historically, individual measures have included items such as delay per traveler, travel time, travel time index, buffer index, and planning time index, while area measures included total delay, congested travel, volume to capacity ratio, and others. More recently, with the advent of MAP-21, the idea of travel reliability has come to the forefront for state DOTs and MPOs. The mobility measures included in MAP-21 are the level of travel time reliability, truck travel time reliability, and peak hour excessive delay. A discussion of some selected mobility measures and metrics is included in the following sections.

Common Congestion Performance Metrics

Evaluating or developing performance metrics to measure congestion is not the intent of this thesis. Therefore, the analysis relies on a basic comparison of corridor travel times along with measures of travel time reliability. FHWA has been promoting the idea of travel time reliability as the best way to measure congestion for at least the last 15 years [33]. FHWA defines travel time reliability as a measure of the consistency, timeliness, predictability and dependability of a trip [34]. FHWA identifies travel time index (TTI), buffer index (BI), and planning time index (PTI) as 3 of the most common reliability metrics. These three metrics, along with the segment travel time itself, are described below per FHWA [34].

Travel Time (TT)

The travel time is defined as the observed travel time in seconds or minutes for a given segment or corridor. As previously noted in Chapter 2, one of the data elements included in the NPMRDS data file is the mean travel time (TT_{Mean}) for each 5-minute period of each TMC segment.

Travel Time Index (TTI)

The travel time index is defined as the ratio of observed mean travel time to the travel time during free flow conditions. Also in Chapter 2, one of the data elements included in the NPMRDS data file is the *reference speed*, which serves as an approximation of the free flow speed for a given TMC segment.

$$TTI = \frac{TT_{Mean}}{TT_{Free\ Flow}}$$

Buffer Index (BI)

The buffer index is defined as the additional time cushion that motorists must plan for to ensure an on-time arrival 95 percent of the time.

$$BI = \frac{TT_{95\%} - TT_{Mean}}{TT_{Mean}}$$

Planning Time Index (PTI)

The planning time index is defined as the ratio of the observed 95 percentile travel time to the travel time during free flow conditions.

$$PTI = \frac{TT_{95\%}}{TT_{Free\ Flow}}$$

MAP-21 Mobility Metrics

MAP-21 established the Transportation Performance Management (TPM) framework that outlines the rules that state DOTs and MPOs must follow when reporting the condition and performance of their respective transportation systems to the federal government as a condition of federal funding. The TPM program was later reinforced by the subsequent transportation legislation referred to as the FAST Act.

The TPM rules are intended to address six interrelated performance factors that collectively address challenges facing the transportation system in the United States: (1) improving safety; (2) maintaining infrastructure condition; (3) reducing traffic congestion; (4) improving efficiency of the system and freight movement; (5) protecting the environment; and (6) reducing delays in project delivery [35]. The TPM rules establish targets for applicable measures that states must report on. Three of the measures deal directly with the mobility of individual travelers and freight on the NHS. The measures are as follows:

1. Percent of person miles travelled on the Interstate that are reliable
2. Percent of person miles travelled on the non-Interstate NHS that are reliable
3. Truck travel time reliability

Each measure is based on the calculation of an underlying metric that was defined as part of the TPM rulemaking process. The first two measures are based on the same metric – the level of travel time reliability. The third measure is based on the truck travel time reliability index. Each metric is described in the following subsections.

Level of Travel Time Reliability (LOTTR)

The LOTTR is defined as the ratio of the observed 80th percentile travel time to the travel time during normal conditions (50th percentile). The LOTTR is based on the travel times of passenger cars only. For MAP-21 and FAST Act purposes, it is evaluated for four time periods that represent weekday morning, midday, and evening periods along with an all day period on the weekends.

$$LOTTR = \frac{TT_{80\% PC}}{TT_{Mean PC}}$$

Truck Travel Time Reliability (TTTR)

The TTTR is also defined as the ratio of the observed 80th percentile travel time to the travel time during normal conditions (50th percentile). However, the TTTR is based on the travel times of trucks only. For MAP-21 and FAST Act purposes, it is evaluated for the same four time periods as the LOTTR, but an additional fifth period is included that represents the overnight conditions on weekends.

$$TTTR = \frac{TT_{80\% Trucks}}{TT_{Mean Trucks}}$$

Travel Time Cumulative Distribution Functions (CDF)

Each of the congestion metrics described above have one thing in common – they all rely on the idea of comparing percentiles of travel time distributions to describe the reliability characteristics of a corridor or trip. While each of the metrics can be used to quantify specific reliability-related characteristics, considering all of the metrics at the same time can be challenging and only considering one can be misleading. When evaluating causal factors (both

internal and external) between two separate travel time distributions representing different conditions on a given corridor, determining the presence of an “influencing factor” causing the congestion or unreliable travel can be visualized (rather than calculated) by comparing the size and shape of the CDF plots [36]. This type of visual comparison is the strategy that was employed for the evaluations associated with the first two case study assessments.

Figure 8 is used to further illustrate the comparison technique and how it relates to congestion and travel time reliability evaluations. Figure 8 shows CDF plots for two different travel time conditions TT1 and TT2. For discussion purposes, let’s say TT1 represents the vehicle travel times on the subject corridor when container vessels *were not* present at the port and TT2 represents when container vessels *were* present at the port. In Figure 8(a), the CDF shows what is expected if roadway congestion was worse overall when container vessels were in port since the entirety of the TT2 line is to the right of the TT1 line. Another way to describe it is that the TT_{Mean} would be worse in TT2 when compared to TT1, as well as the TTI and PTI since these measures are based on the free flow travel time (FFTT or $TT_{Free\ Flow}$) for each condition, which is the same. Also, since the two curves appear fairly parallel, it’s possible that the BI, LOTTR, and TTTR may actually be the same for both TT1 and TT2.

Figure 8(b) illustrates an example where the TT_{Mean} is the same for both TT1 and TT2, so you cannot say that overall congestion is worse in TT2, as was the case in Figure 8(a), but since TT2 is to the right of TT1 at the upper percentiles, then you could say TT2 is less reliable than TT1 and the associated TTI, BI, PTI, LOTTR, and TTTR are all worse when compared to TT1.

Figure 8(c) illustrates a third example (among many other possibilities) where the 80th percentiles are the same for TT1 and TT2 and thus the LOTTR and TTTR are the same as well.

Therefore, the conditions for TT1 and TT2 are equally reliable when using LOTTR and TTTR. However, when considering the 95th percentile as required for BI and PTI, the conditions associated with TT2 are considered less reliable than TT1.

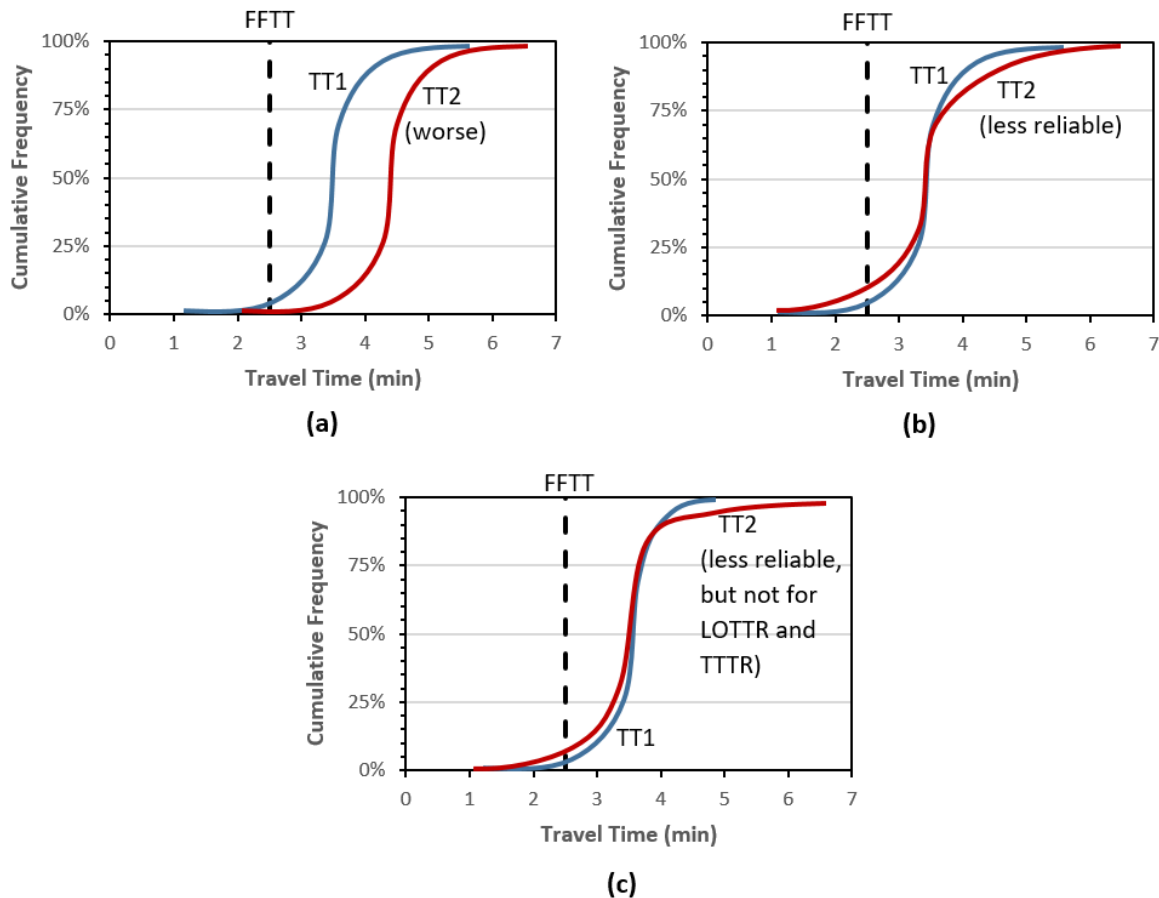


Figure 8. Example CDF Scenarios

Figure 8 ultimately illustrates that using a single metric to describe the difference in congestion and travel time reliability between two conditions can be misleading depending on the metric, or combination of metrics, used. Therefore, this thesis used the approach of comparing CDF plots between two seemingly different conditions since this type of comparison can paint a more complete picture when trying to assess each condition's impact on congestion and reliability for a given roadway corridor.

Chapter 4: Congestion Trend Analytics

Each of the metrics described in Chapter 3 can be computed at the segment level (i.e. TMC segment) or at the corridor level (i.e. a collection of continuous TMC segments). They can also be calculated for a variety of temporal schemes: time of day, day of the week, weekday, weekend, monthly, annually, and various combinations (e.g. time of day for weekdays). There are countless combinations that can be used to provide a full range of statistics for different users and use cases. Using the NPMRDS data covering the New Orleans area for 2016 to 2018, some of the potential combinations were explored to aid in the selection of the study corridor, congested periods, and days of the week used in the analysis.

Corridor Selection

Container truck traffic from the Port of New Orleans has origins and destinations from the West via Interstate 10 (I-10), the North via Interstate 55 (I-55), the South via US90-Business (US90-B), and the East via I-10. Figure 9 shows a map of the study area, the location that container-related port traffic accesses the freeway system on US90-B (indicated by the red arrow), and the section of I-10 that was ultimately used in this study (indicated by the red and white dashed line). At first glance, the logical point to begin the study corridor would be the point at which container trucks enter or leave the freeway system (red arrow) on US90-B. However, the disparity between the NPMRDS data coverage of non-interstate routes versus interstate routes is a factor that required consideration. The NPMRDS data covers the entire NHS, so each of the interstate routes serving Port NOLA have equivalent data coverage which is contractually required to be at least 85% during peak periods, but the non-interstate routes are only required

to have a minimum coverage of 35% during peak periods [27]. The interstate NPMRDS data offers a significantly more complete (temporally) option for the analysis. Therefore, the point (TMC segment) at which the container traffic first interacts with the NPMRDS network on the interstate was chosen as corridor terminus on the eastern side of the study area.

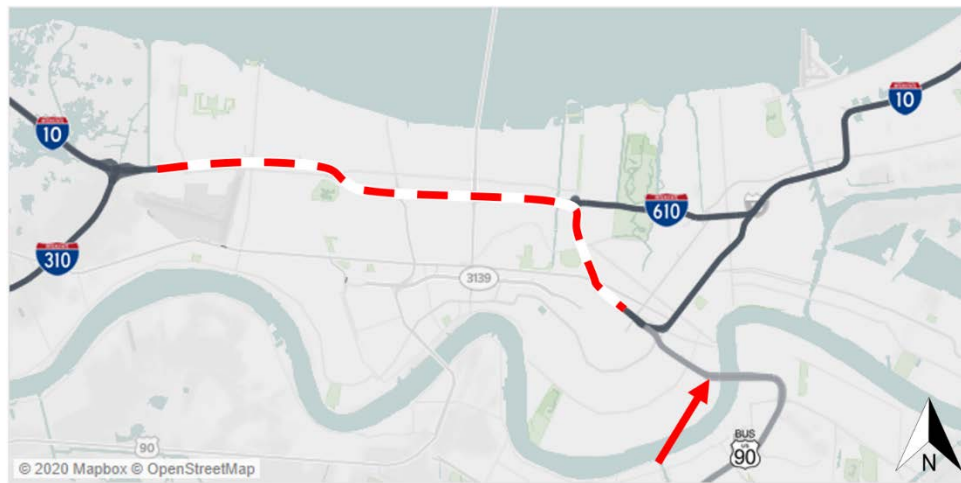


Figure 9. Map of study area (New Orleans)

In selecting the western terminus of the study corridor, the availability of complementary data sets was considered. Publicly available traffic cameras, whose coverage is indicated by the red circles in Figure 10, could be used as a source for vehicle classification and traffic volume data collection in areas where comprehensive data does not currently exist. As the figure shows, all of I-10 in the New Orleans area has good camera coverage. However, I-10 just east of the I-310 interchange has one thing that none of the other stretches of I-10 have – a permanent vehicle count station that also classifies vehicles (indicated by a red “x” in Figure 10). Therefore, the western corridor terminus was chosen to be on the West approach to New Orleans since the presence of a permanent count station affords the possibility of validating whether the results

from the trend analyses can truly be attributed to the differences in the scenarios or are they attributed to fluctuations in overall traffic volumes or truck percentages.

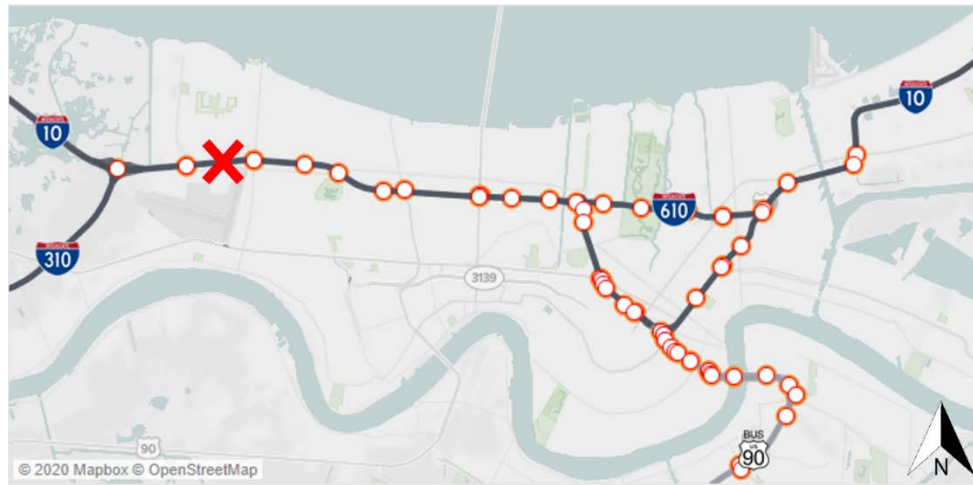


Figure 10. Map of DOTD cameras in New Orleans

Since this thesis requires congested segments to be analyzed, a final consideration in determining the exact location (TMC segment) of the western terminus was verifying the existence and extent of the routine congestion for this stretch of I-10. Using speed as an indicator of congested conditions, Figure 11 shows the average weekday speeds from the NPMRDS during the morning and evening rush hours. Green indicates free flow conditions, and yellow, orange, and red indicates varying levels of congestion from lightest (yellow) to heaviest (red). The figure verifies that routine congestion occurs along I-10 and extends to the TMC segment just east of the I-310 interchange – the western terminus of the study corridor. Figure 11 also shows that congestion is consistently more present in the eastbound direction for both morning and evening peak periods than the westbound direction. Since the eastbound direction contains congestion in both the morning peak and the evening peak, the remainder of the analyses focused on the eastbound direction only.

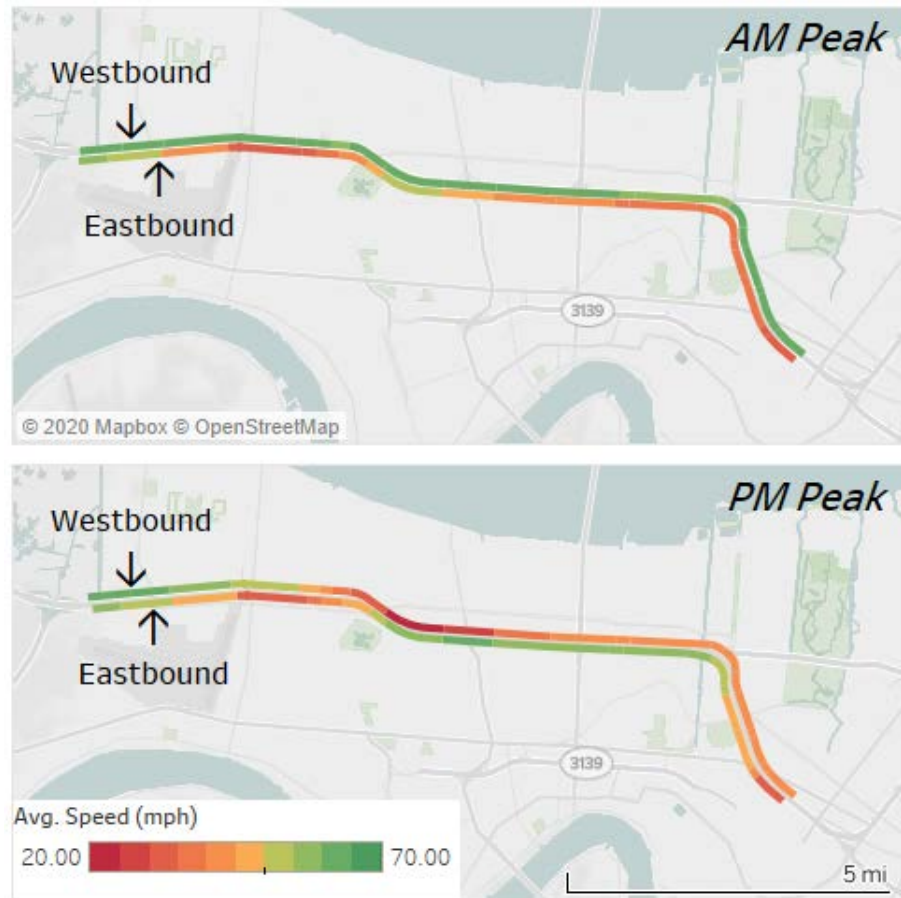


Figure 11. Weekday (Mon - Thurs) average speeds of study corridor

Identifying Sub-corridors

The speeds for each of the TMC segments within the corridor were plotted temporally to determine if sub-corridors existed based on likenesses in the shape and progression of their profiles, that is, were they building in severity until a release point followed by another build and release cycle. While not shown here, the results of that exercise are reflected in the congested period identification discussion below (see Figure 14). Six different sub-corridors, or sections, were identified and are labeled alphabetically from east to west starting with letter “A”. The map

in Figure 12 shows the location of each sub-corridor as well. From this point forward, the terms “sub-corridor” and “section” should be considered interchangeable and were used as such.



Figure 12. Sub-corridor map

The TMC segments included in the final corridor and sub-corridor selection are detailed in Table 1. Overall there were 23 TMC segments and six sub-corridors identified for inclusion in the analysis. The table also includes pertinent data fields for each that were used in the remainder of the analysis such as the TMC segment length and reference speed (free flow speed). In addition, the table includes the number of speed and travel time observations available from the NPMRDS between 2016 and 2018 for each TMC segment.

Table 1. Corridor Details

Sub-corridor (or Section)	TMC Segment Code	Length (miles)	Free Flow Speed (mph)	Minimum Number of Observations	Maximum Number of Observations
(A) I-310 to Power	113-04102	0.441	71	365,940	684,446
	113-04103	1.017	70	445,378	749,826
	113N04102	0.819	70	375,472	695,412
	113N04103	1.122	70	471,056	770,968
(B) Power to Veterans	113-04104	0.233	72	491,066	786,106
	113-04105	0.461	71	546,646	822,032
	113N04104	0.320	72	497,200	790,940
	113N04105	0.295	71	501,864	791,812
(C) Veterans to Bonnabel	113-04106	0.956	71	536,150	815,482
	113-04107	0.964	71	584,490	845,388
	113N04106	0.782	72	468,278	775,794
	113N04107	0.880	72	467,436	774,082
(D) Bonnabel to I-610	113-04108	0.209	72	551,972	820,462
	113-10374	1.010	72	626,916	868,730
	113N04108	0.0137	72	524,456	802,884
(E) I-610 to Metairie Rd.	113-04109	0.381	73	241,280	559,980
	113-04110	0.162	70	290,524	614,280
	113-04111	0.169	73	252,790	572,330
	113N04109	0.489	71	255,324	577,066
	113N04110	0.418	70	275,538	599,210
(F) Metairie Rd. to US-90B	113-04112	0.155	71	185,118	486,518
	113N04111	0.658	76	219,778	534,994
	113N04112	0.551	71	216,952	531,928
Totals		12.506		9,391,624	16,270,670

The reason there is a minimum and maximum number of observations in Table 1 relates to the way the data density field is defined (see Chapter 2). For the full 12.506 mile study corridor, the NPMRDS data represents at least 9,391,624 observations and as much as 16,270,670 observations from which the analyses in the following section are based on.

Day Selection

In order to determine which days of the week to include in the analysis, the speed profiles were plotted by day of the week for each of the sections. Figure 13 shows the profile for each of

the four TMC segments in section A from 4am – 10pm, which reveals that a fairly consistent recurring congestion pattern occurs on Monday through Thursday in terms of intensity and duration. Friday through Sunday each have unique profiles that are likely heavily influenced by special events occurring in and around the city each weekend. Also, container terminal operations are typically limited on the weekends which would effectively minimize the potential presence and impact of container trucks on the interstate traffic stream. Therefore, the weekend days (including Friday) were not included in the remainder of the analyses since their patterns were so drastically different than the Monday through Thursday pattern.

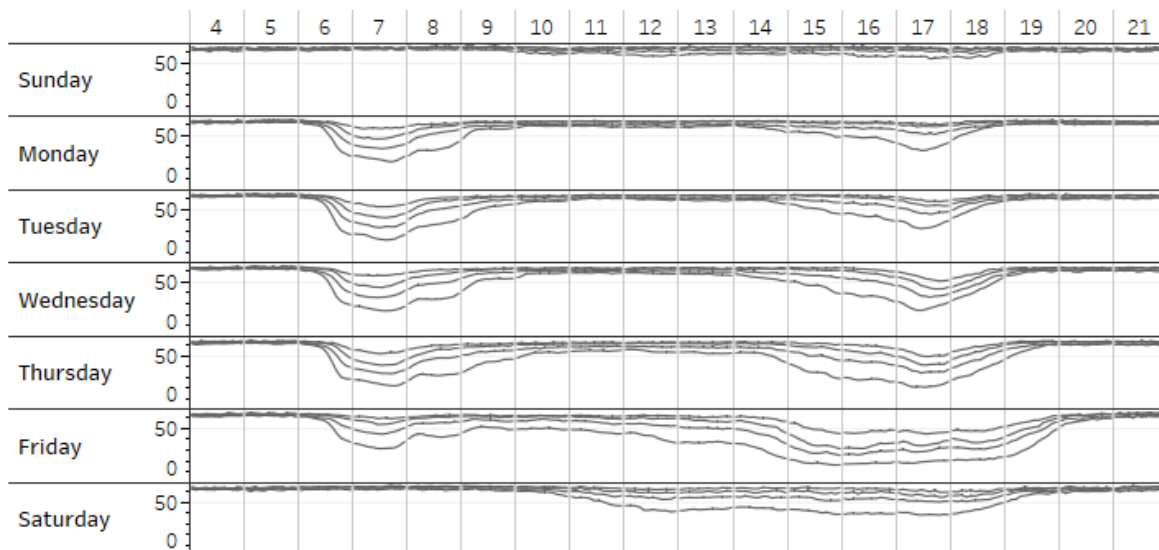


Figure 13. Section A speed profiles by day of the week

Congested Period Identification

This thesis is based on an evaluation of congestion so the analysis period was restricted to congested periods. To identify the congested periods, the speed profiles from the NPMRDS data were again plotted for each of the sections A – F and are shown in Figure 14. The arrows in the figure indicate the direction of travel.

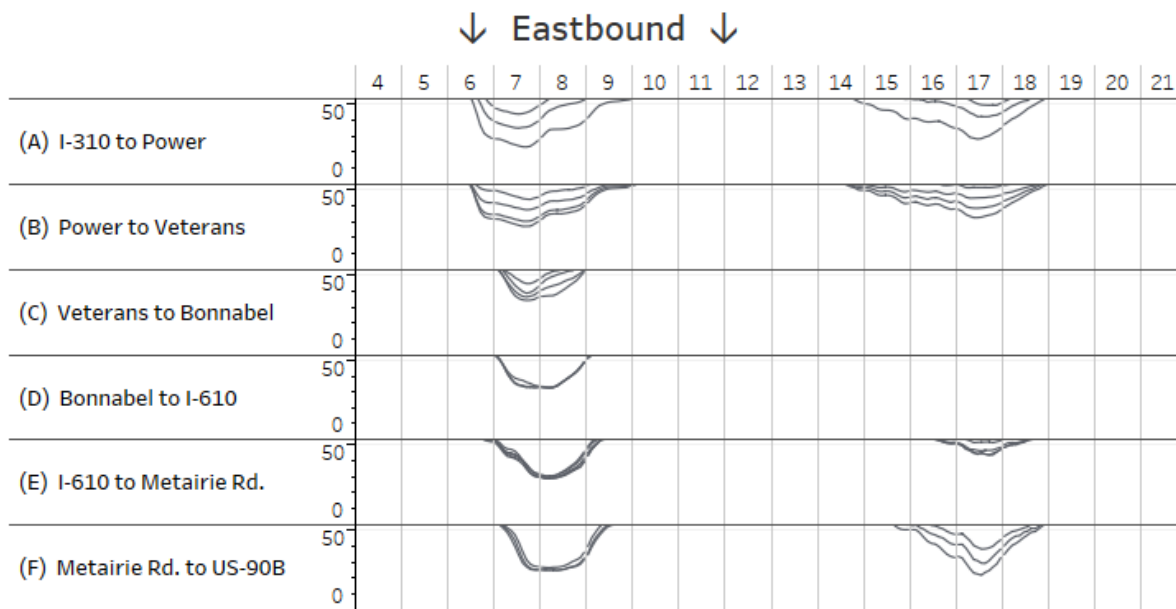


Figure 14. Sections A - F speed profiles showing congested periods

To aid in this visual identification of the congested periods and remove the noise associated with the non-congested conditions, you'll notice that higher speeds (above 53.3 mph) were excluded from profiles. While the relationship of travel speed to congestion was not specifically addressed in Chapter 3, it should be noted that travel time and speed are directly related and some technical references have used speed as an indicator of congestion as well. One such reference, the Highway Capacity Manual (HCM), provides that the fundamental definition of congestion is when the capacity of a roadway is exceeded. The six decades of research behind the HCM has resulted in, among many other things, the guidance that the maximum capacity of a freeway with a free flow speed of at least 70mph is achieved at an operational speed of 53.3mph (Exhibit 23-2 of the HCM) [37]. Table 1 showed that all of the TMC segment free flow speeds are above 70 mph. Therefore, speeds below 53.3mph could be considered congested conditions. Visual inspection of Figure 14 reveals that there is a two hour

block of time in both the morning and evening period where the bulk of the congestion occurs. Therefore, the congested periods used in the remainder of the analysis are 7am – 9am and 4pm – 6pm.

Impact of Container Vessel Presence

To determine if vessel data can be used in conjunction with vehicle probe data to characterize the impact of the presence and count of container vessels in port, the CDFs of travel times from the NPMRDS were plotted for each TMC segment and for each vessel data source (AIS and E&C). The full set of CDFs for each TMC segment by sub-corridor can be found in Appendices B and C for AIS and E&C, respectively. For discussion purposes, only the worst case segment for each sub-corridor is included in the figures and discussions below since visual inspection of the full set of CDFs reveals that the worst case yields the clearest results for each sub-corridor. However, the following discussions apply to the other TMC segments within each sub-corridor as well.

AIS-based Analysis

The CDFs of NPMRDS travel times for the AIS-based data for sections A – C and D – F are shown in Figure 16 and Figure 17, respectively. The plots are shown for the AM peak period and the PM peak period for a sample TMC segment in each sub-corridor. The location of the sample segment from each sub-corridor is shown in Figure 15.



Figure 15. Location of sample TMC segments

The corresponding segment length and TMC code is also shown for additional context. The plots include three lines representing the number of container vessels in port according to the AIS data. The blue line represents the travel time observations where no container vessels were in port. The green and orange lines represent the travel time observations where one vessel and two or more vessels were in port, respectively. Referring back to the table in Figure 4 shows that there was a large drop-off in the count of observations when three or more vessels were in port so they were lumped into the “2 or more vessels” category to ensure a more than adequate number of data points to not need further statistical analysis.

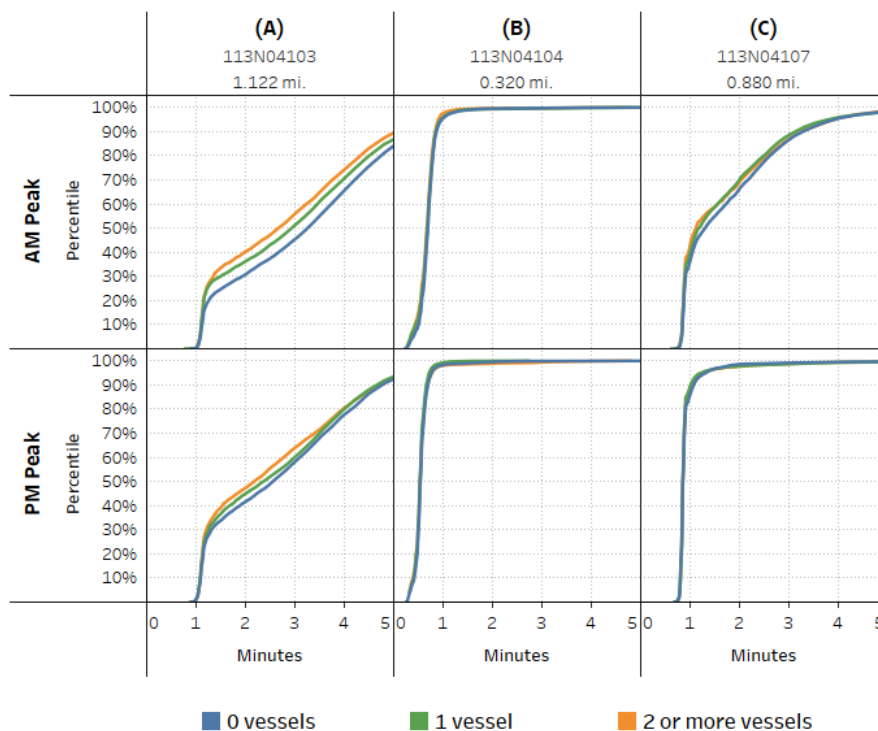


Figure 16. Sample CDFs based on AIS for Section A-C

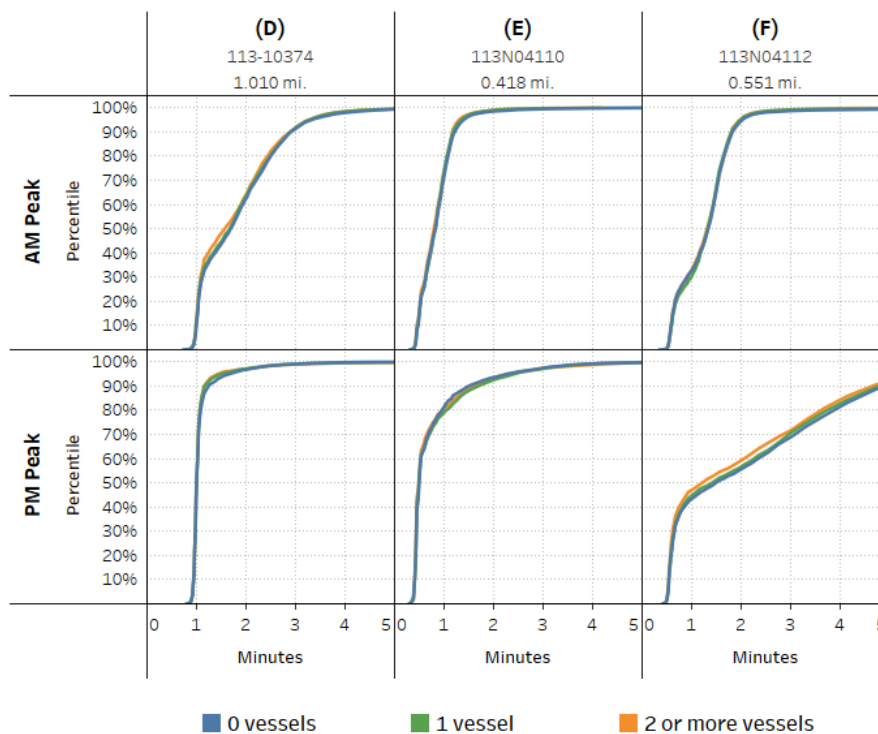


Figure 17. Sample CDFs based on AIS for Section D - F

Many of the segments show the three lines closely stacked on one another which suggests that for those segments, there is no clear indication that container vessel presence or count impacts congestion. If the assumption that the presence and count of container vessels in port has an adverse effect on interstate congestion were to hold true, the expected result where differences occur would be a progression of lines from left to right or top to bottom with a blue-green-orange order. However, for the AM peak period of section A and C and the PM peak period of section A and F, the complete opposite order is shown. That is, the blue line (or no vessels condition) is to the right of the orange and green lines. Therefore, the data suggests that traffic congestion is better and more reliable when container vessels are in port.

While this finding would be music to the ears of trucking and port officials, the suspected source of this confounding result was in the AIS data itself. One of the benefits of including E&C data in this thesis is that according to discussions with USACE officials, E&C data is considered authoritative when compared to AIS data since AIS data is based on GPS information, and E&C data is based on customs information. Presumably, there are much more severe consequences to falsifying customs documents than there are for having a mis-programmed AIS unit. Therefore, the E&C data is considered the ground truth and can be compared with the AIS data to determine if there are missing vessels or rogue vessels in the AIS dataset. There are also issues with the AIS data that are known to USACE officials that can result in discrepancies when comparing them with E&C data. One example issue is if an AIS message has vessel information that has been entered incorrectly, such as an oil tanker having its vessel type labeled as 'cargo' in the message, that inaccuracy could cause that vessel from being included in your data set if you are filtering by vessel type.

The AIS data was compared to the E&C data for this case study and revealed that 32 container vessels representing 167 port calls at the Port NOLA container terminals had no partner record in the AIS data from 2016 -2018. With the total number of container vessel port calls in the E&C data at 1579, this means the AIS data was missing about 10.6% of the port calls which could explain the unexpected results in the CDFs in Figure 16 and Figure 17. Some of that 10.6% of missing data could be the result of discrepancies between how the AISAP Tool user drew their area of interest (AOI) boundary and how it relates to the US Customs-defined area used in the E&C data. If the AOI is drawn smaller than the US Customs-defined area, then any vessels arriving at docks which are physically located outside of your AIS query area would not be included in the query results.

Another potential issue with the analysis is that in joining the 5-minute periods of the NPMRDS with the 5-minute periods of the AIS dataset, like periods were joined. For example, if according to the AIS data, 2 vessels were in port at 10:05 am, then the corresponding NPMRDS data at 10:05am was used to represent vehicle travel times at that 2-vessel condition. While the flaw in this approach is that it disregards the time it takes for the first container to actually make it from the vessel to the highway or subsequent highway segments (remember, this thesis is intentionally dealing with congested segments so the travel times could get lengthy), or vice versa, its resulting effects are likely limited to the beginning and ending periods of the port call. Also, there is an unknown time associated with unloading/loading containers and transporting them through the terminal to the truck gates.

E&C-based Analysis

The CDFs of NPMRDS travel times for the E&C-based data for sections A – C and D – F are shown in Figure 18 and Figure 19, respectively. The plots are shown for the AM peak period and the PM peak period for a sample TMC segment in each sub-corridor. The corresponding segment length and TMC code is also shown for additional context. The plots include four lines representing the number of container vessels in port according to the E&C data.

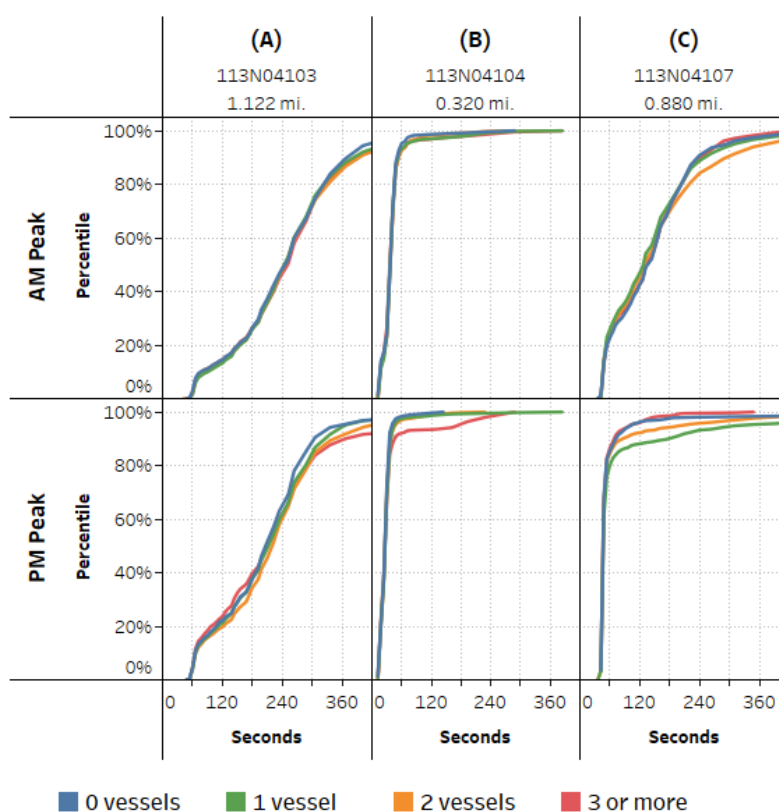


Figure 18. Sample CDFs based on E&C data for Section A-C

The blue line represents the travel time observations where no container vessels were in port. The green, orange, and red lines represent the travel time observations where one vessel, two vessels, and three or more vessels were in port, respectively. Referring back to the table in Figure 5 shows that there was a large drop-off in the count of observations when four or more

vessels were in port so they were lumped into the “3 or more vessels” category to ensure a more than adequate number of data points to not need further statistical analysis.

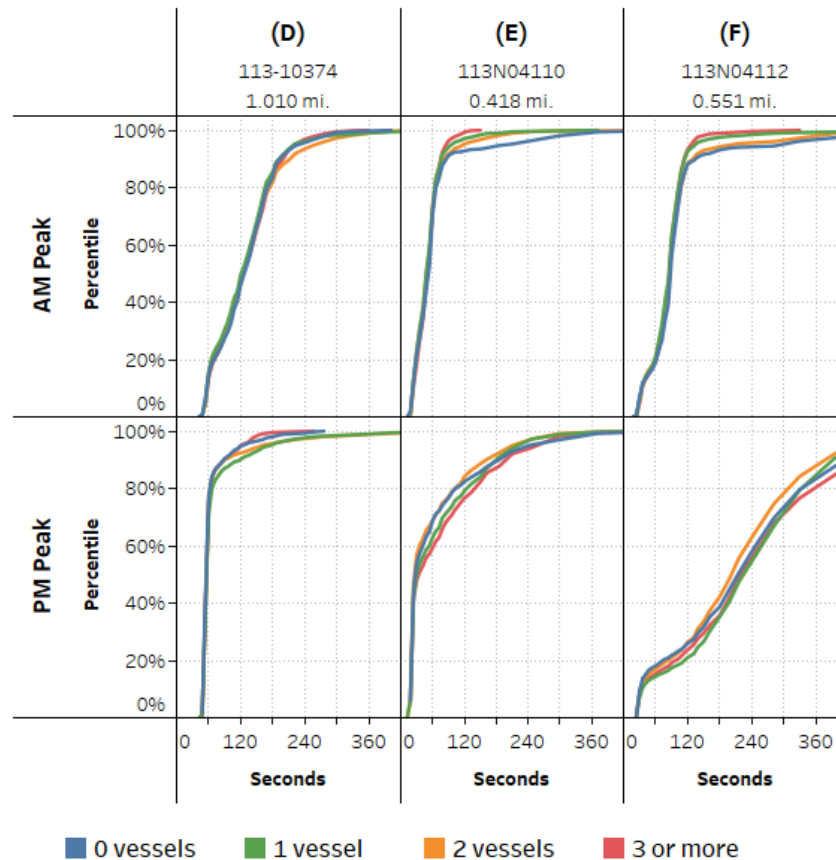


Figure 19. Sample CDFs based on E&C data for Section D-F

If the assumption that the presence and count of container vessels in port has an adverse effect on interstate congestion were to hold true, the expected result when reviewing the plots would be a progression of lines from left to right or top to bottom with a blue-green-orange-red order. Section A follows that pattern nicely which would suggest that the E&C data could be an good indicator of variations in congestion due to vessel presence or count. However, inspection of the other sections reveals the sobering truth that, like AIS data, E&C data yields questionable results. For example, when reviewing the travel time reliability portion of the CDF (80th percentile

and above), the PM peak period of section C shows a condition where 1 vessel in port (green line) is the worst reliability and 3 vessels in port (red line) is the best reliability – even better than no vessels in port (blue line). Another questionable result can be found in the AM peak periods of sections E and F. Like the previous AIS-based analysis, these two plots show conditions where no vessels in port results in worse travel time reliability than when vessels are in port.

One possible explanation of these questionable results could lie within the temporal resolution of the E&C data. The main difference between the AIS data and the E&C data is the granularity of the temporal data associated with each. The AIS data is time-stamped based on 5-minute bins of information, whereas the E&C data is date-stamped based on full day (24 hour) bins of information. This full day representation likely results in an over-representation of time periods with multiple vessels in port. One straight forward example is if a vessel departs at 2am on a given day and another vessel arrives at 9pm of the same day with no vessels in port during the 2am-9pm window, the E&C data would show that day as having two vessels in port for the full day including the AM and PM peak periods. Whereas, the AIS data would show no vessels in port during the peak periods. One way to illustrate this over-representation is by combining the two calendars in Chapter 2 as shown in Figure 20.

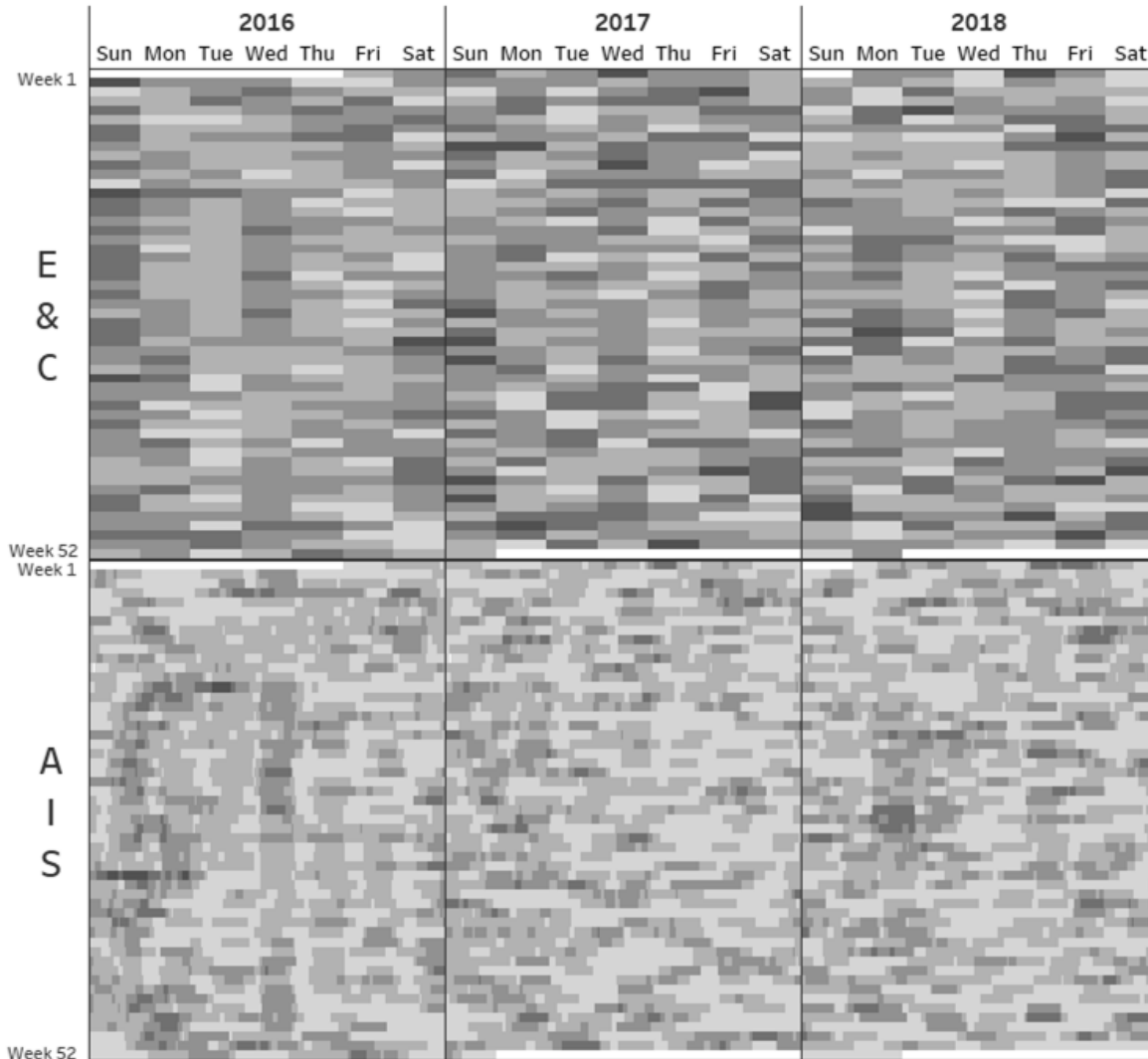


Figure 20. Combined vessel count calendar from AIS and E&C data

Figure 20 demonstrates the different granularities between the AIS data and the E&C data. The shading scales are identical in both datasets with the lightest gray representing no vessels in port and the darkest gray representing 4 vessels in port. Visually comparing the top half (E&C data) to the bottom half (AIS data) reveals an overall darker tone to the E&C data.

Impact of Container Vessel Size

To determine if vessel data can be used in conjunction with vehicle probe data to characterize the impact of container vessel sizes in port, it was envisioned that a similar approach to the vessel presence and count exercise would be employed. That approach was used for the E&C-based analysis detailed below. After exploring the vessel dimension fields in the AIS data, it was determined that AIS data would not support such an analysis technique.

The culprit in the AIS data are the fields intended to represent the vessel dimensions – the length and width. A close inspection of the data showed that many of the vessels in the dataset had their length and width dimensions identified as zero, which represented 154 port calls out of a total of 1345. Discussions with USACE officials revealed that these dimensionless vessels were playfully referred to as ‘ghost ships’. With that number of records missing dimension data, which translates to about 11.4% of the total port calls, and coupled with the issue of missing records discovered in the vessel presence and count analysis, it was determined that an AIS-based analysis of vessel size impacts on interstate congestion would be futile, and thus, not conducted in this thesis. Even if the data issues were fixed, the analysis is likely not worthwhile based on the container vessel presence findings above, the E&C findings below, and the discussion in Chapter 5.

E&C-based Analysis

The NRT, or net registered tonnage, is the E&C vessel dimension data used in this analysis since, despite its name, it is a volume measurement intended to represent the volume of available revenue earning space on a given vessel. In the case of container vessels, the revenue

generating space is where the containers go and should serve as a good proxy for the TEU capacity of a vessel.

In order to conduct the analysis, the cumulative NRT for each vessel in port on a given day was calculated and associated in the data for the time period in question. To assist in evaluating varying cumulative sizes of the vessels in port, the cumulative NRTs were divided into the four ranges shown in Table 2. Several combinations of ranges were considered until a set of ranges was selected that ensured provided a fairly even distribution of TT observations.

Table 2. Cumulative NRT Ranges and Count of Travel Time Observations

Cumulative NRT Ranges	Count of TT Observations (AM, PM, M-Th)
0	408,576
5,000 – 33,999	989,184
34,000 – 62,999	1,102,080
> 63,000	860,160

To determine if E&C-based vessel data can be used in conjunction with vehicle probe data to characterize the impact that the size of container vessels in port has on interstate congestion, the CDFs of travel times from the NPMRDS were plotted for each TMC segment. The full set of CDFs for each TMC segment by sub-corridor can be found in Appendix D. However, for discussion purposes, only the worst case segment for each sub-corridor is included in the figures and discussion below since visual inspection of the full set of CDFs reveals that the worst case yields the clearest results for each sub-corridor. However, the following discussions apply to the other TMC segments within each sub-corridor as well.

The CDFs of NPMRDS travel times for the E&C-based data for sections A – C and D – F are shown in Figure 21 and Figure 22, respectively. The plots are shown for the AM peak period and

the PM peak period for a sample TMC segment in each sub-corridor. The corresponding segment length and TMC code is also shown for additional context. The plots include four lines representing the NRT of container vessels in port according to the E&C data. The blue line represents the travel time observations where the NRT equaled zero (no container vessels were in port). The green, orange, and red lines represents the travel time observations based on the increasing NRT ranges shown in Table 2 and the legend.

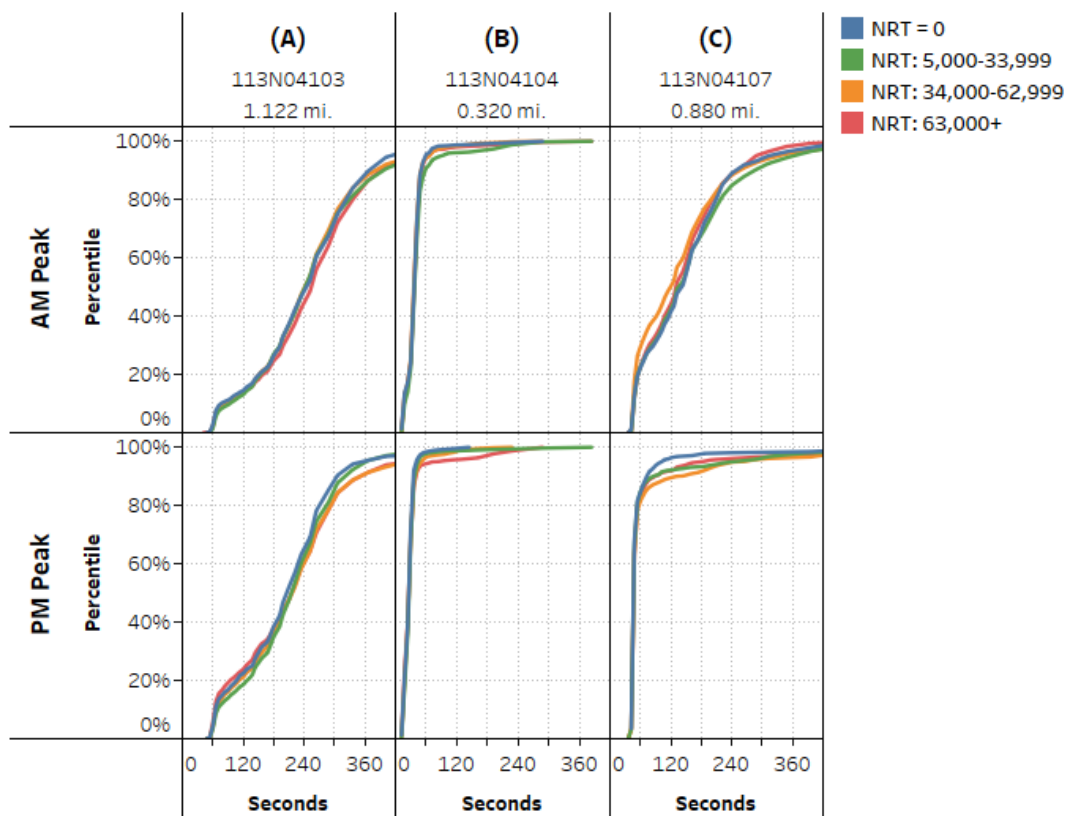


Figure 21. Sample CDFs based on E&C dimension data for Section A-C

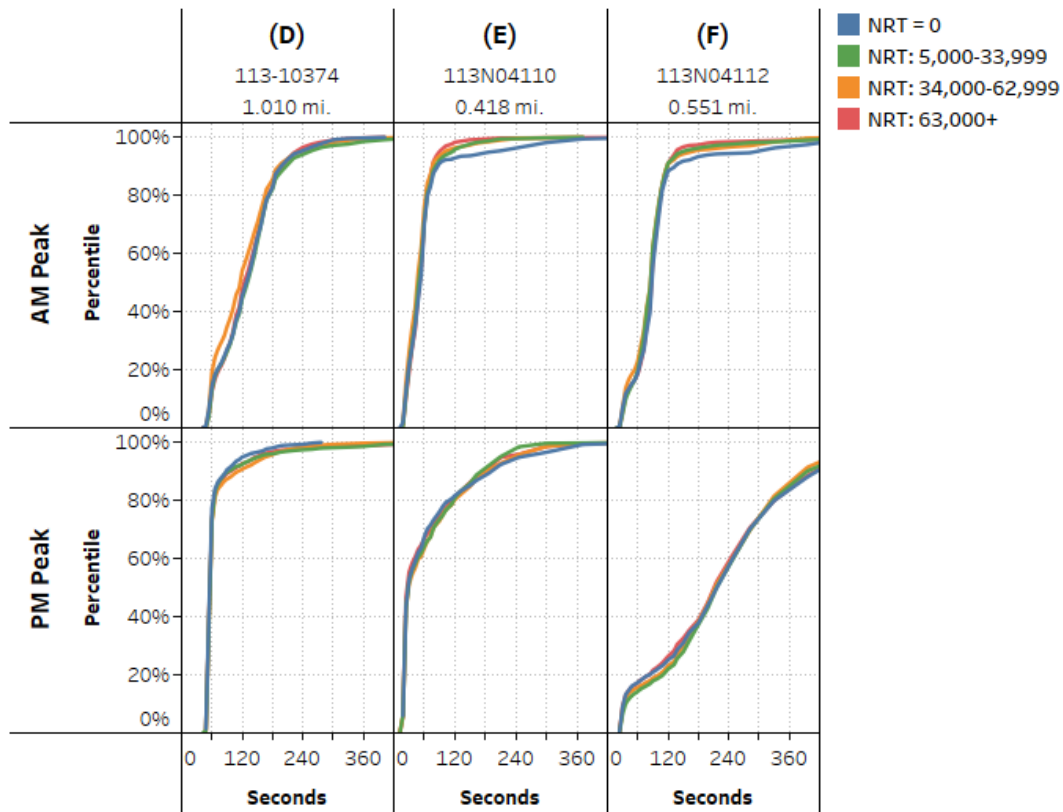


Figure 22. Sample CDFs based on E&C dimension data for Section D-F

If the assumption that the size of the container vessels in port has a relation to and resulting adverse effect on interstate congestion were to hold true, the expected result when reviewing the plots would be a progression of lines from left to right with a blue-green-orange-red order. Inspection of the CDFs reveals the reality that, like the previous CDF analyses, questionable results are abound. There is almost no commonality between the CDFs in each section. The discussion about temporal over-representation in the vessel presence and count analysis based on E&C data applies in this case as well, but will not be repeated. However, another possible contributor to the questionable results is an underlying assumption heretofore not mentioned. That assumption was that vessel size was directly related to actual volume of cargo being handled by the port. If that assumption is false for a given port, as these CDFs

suggest for Port NOLA, then the premise that vessel size can be an indicator of increased interstate congestion is also false. This idea is explored and discussed further in Chapter 5.

Impact of Fluctuations in Container Truck/Chassis Traffic

To determine if vessel data can be used in conjunction with vehicle probe data to characterize the impact of fluctuations in container truck/chassis traffic has on interstate congestion, the CDFs of travel times from the NPMRDS were plotted for each TMC segment based on daily and weekly variations in TEUs (from PIERS data) handled by Port NOLA in October 2019.

The CDFs of NPMRDS travel times for the PIERS-based data using daily and weekly totals are shown in Figure 23 and Figure 24, respectively. The plots are shown for the AM peak period and the PM peak period for four TMC segments in sub-corridor A and the first two segments of sub-corridor B. The corresponding segment length and TMC code is also shown for additional context. These six TMC segments were chosen for this analysis for two reasons. The first reason is that they represent one full build-up and release of congestion. This is evident by the general slope of the line going from vertical to slanted and back to vertical as you move in the direction of travel from west to east (or left to right from A-1 to B-2). The second is that the location of DOTD's permanent count station falls within limits of these six segments (in section A-3). This would allow a comparison of the congestion levels to the actual traffic volume levels at the same date and time to determine if the changes in congestion detected by the CDF method were based on just the normal fluctuations in overall traffic or if they could be attributed to some other event like lower or greater container flows at the port.

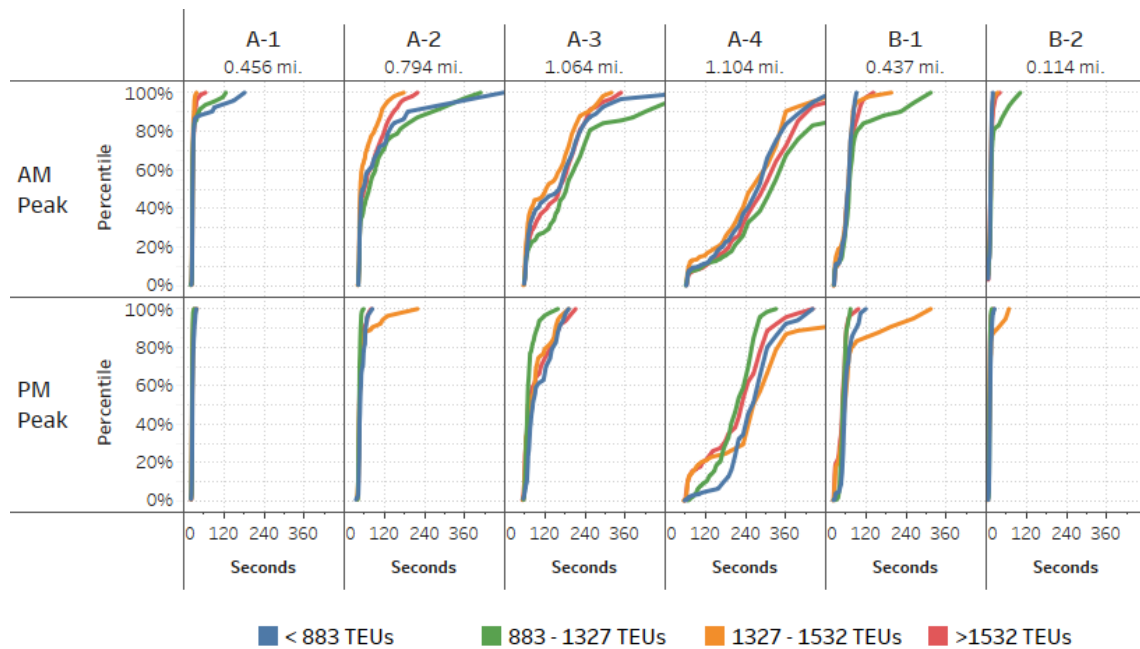


Figure 23. CDF plots based on weekday travel times grouped by TEU Count

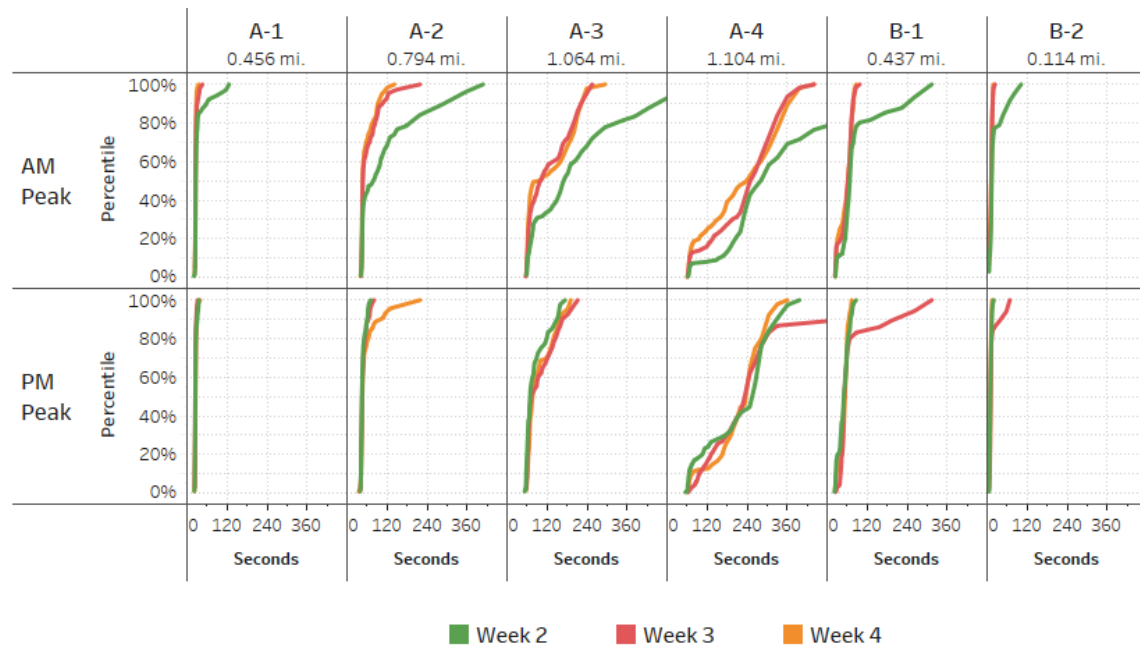


Figure 24. CDF plots based on weekday travel times grouped by week

Daily TEU-based Analysis

The plots in Figure 23 include four lines representing the number of TEUs handled by the port daily according to the PIERS data. The blue line represents the travel time observations of weekdays where less than 883 TEUs were handled. Referring back to Figure 6, there were no days in October 2019 that the port did not handle TEUs to or from vessels. The green, orange, and red lines represent the travel time observations where the port handled 883-1327, 1327-1532, and greater than 1532 TEUs, respectively. These ranges were selected by determining the median and interquartile range of the weekday data which ensures a fairly even distribution of the days in each TEU range.

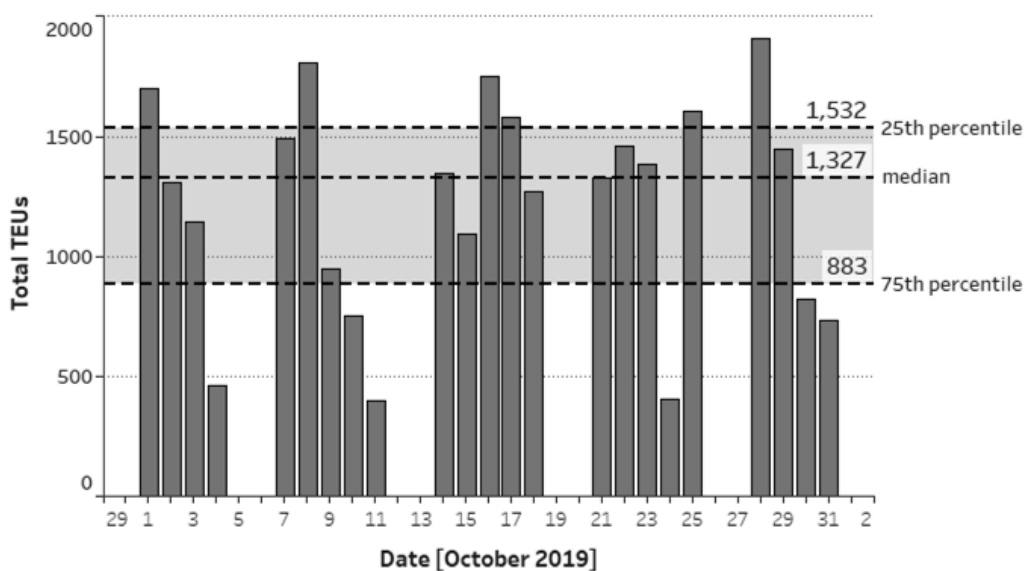


Figure 25. IQR for weekday TEU counts in October 2019 at the Port NOLA

If the assumption that the number of TEUs handled by the port in a given day has a relation to and resulting adverse effect on interstate congestion were to hold true, the expected result when reviewing Figure 23 would be a progression of lines from left to right with a blue-

green-orange-red order. However, visual inspection of the CDFs reveals that, once again, the expected pattern is elusive and there is no commonality between the segments.

The primary suspected source of these questionable results in this case is the daily fluctuations in vehicle traffic not attributable to container trucks. This possibility is explored using the AM peak period of segment A-3 (TMC code 113-4103) where vehicle count information is available from DOTD's permanent count station. Figure 26 summarizes the AM peak period traffic volume data. The colors in Figure 26 correspond to the colors in Figure 23. The full volume count data can be found in Appendix A.

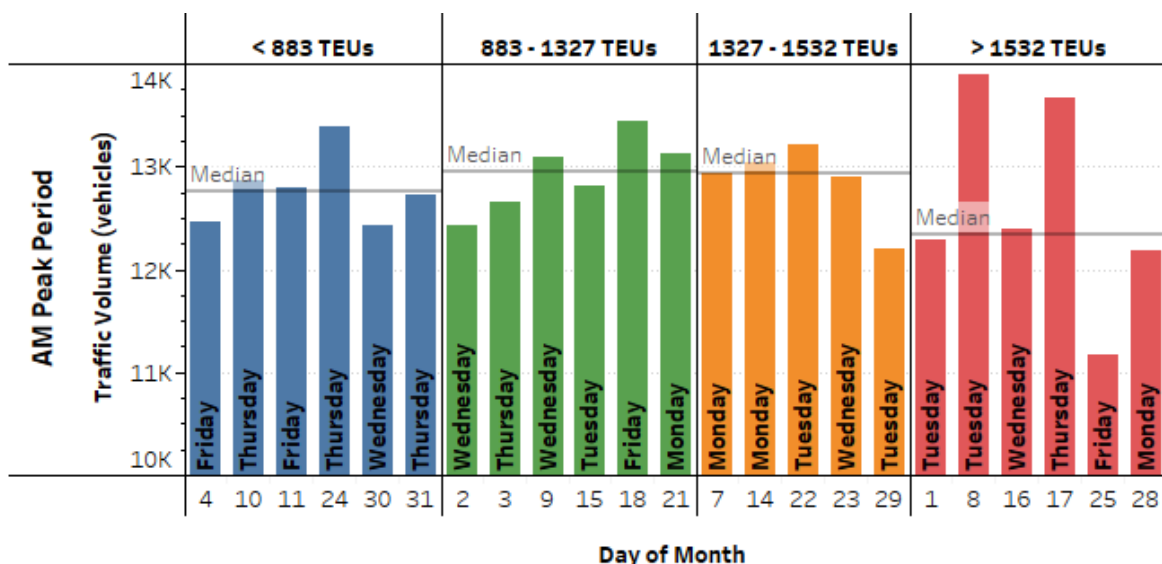


Figure 26. AM peak period daily traffic volumes by TEU range on section A-3

The figure shows that the median (50th percentile) traffic volumes (indicated by the gray line) are fairly similar for the ranges below 1532 TEUs and the individual day totals vary by about 1000 vehicles. However, the red range (> 1532 TEUs) varies by nearly 3000 vehicles in the 2-hour AM peak period. Since the median vehicle counts of the green and orange TEU ranges are nearly identical, it is reasonable to assume that any observed differences in travel times would not be

attributable to fluctuations in traffic volumes. However, the differences could be attributable to makeup of the vehicles in the traffic stream. That is, similar traffic volumes could result in differing congestion levels if there are more trucks in the traffic stream in one TEU range when compared to the other. In this case, theoretically, the orange range should result in a higher percentage of trucks than the green range would. Therefore, if the assumption that the number of TEUs handled by the port in a given day has a relation to and a resulting adverse effect on interstate congestion were to hold true, the expected result when reviewing the AM peak period of Figure 23 would be the orange line to the right of the green line. Once again, the actual result (green to the right of orange) is contradictory to the expected result.

These findings suggest that there are other events and conditions at play that result in the individual days experiencing something lesser or greater than the routine traffic conditions. The effects of those non-routine conditions or events could be overcome by the data smoothing benefits from a much larger/longer PIERS dataset. Unfortunately, this idea could not be explored further since the PIERS data made available by IHS Markit, Inc. for this thesis only covered October 2019.

Weekly TEU-based Analysis

A similar analysis was conducted by grouping the PIERS data by weekly totals rather than TEU ranges. The plots in Figure 24 include four lines representing the number of TEUs handled by the port weekly according to the PIERS data. The green line represents the travel time observations during week two, the red line for week three, and the orange line for week four. Since the first and fifth weeks in October did not represent a full week of data, they were

excluded from the analysis. A summary of the data associated with weeks two through four is shown in Figure 27.

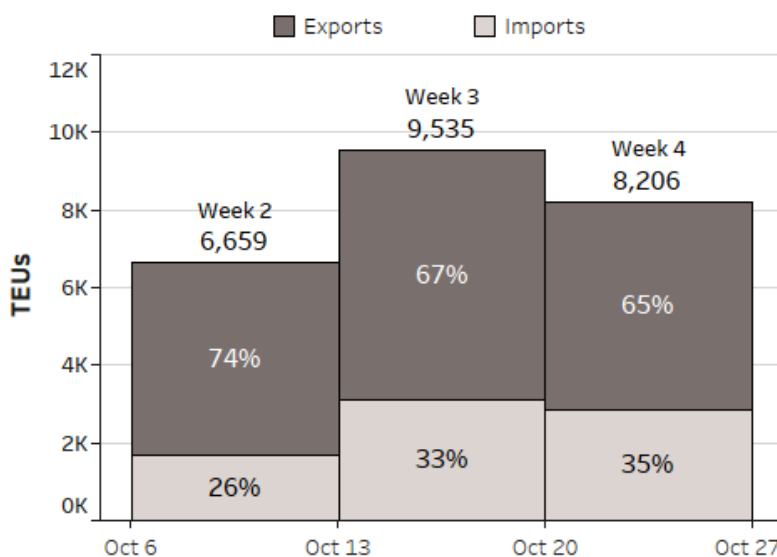


Figure 27. Weekly TEU totals in October 2019 at the Port of New Orleans

When inspecting Figure 24, the recurring theme of unexpected results continues. Again, if the underlying assumption that the number of TEUs handled by the port in a given week has a relation to and resulting adverse effect on interstate congestion were to hold true, the expected result would be a progression of lines from left to right or top to bottom with a green-orange-red order. The figure reveals numerous examples of line order that is contradictory to the expected order. The discussion of possible causes detailed in the daily E&C based analysis applies to the weekly analysis as well and, for brevity sake, is not repeated here.

Impact of COB Intervention

Utilizing CDFs, as employed in the previous sections, to determine the impacts that the introduction of container on barge (COB) service to the Lower Mississippi River has had on interstate congestion would theoretically work if the appropriate data was readily available.

Spatial, temporal, and physical information about specific vessel movements involved in the COB service (in this case, the tug boats pushing the barges) would be needed to use the CDF approach. Conceivably, using the USACE's AISAP Tool would provide the temporal and spatial data needed if you either know which vessels are making that specific voyage or know the origin(s) and destination(s) down to which docks load/unload containers on barge. Efforts were made with the Port of Greater Baton Rouge to acquire the needed information since the COB service is operated by Seacorp AMH, LLC out of the Port's Inland River Marine's Terminal. The discussions with the Port and Seacorp AMH indicated that while the specific dock used for COB service on the Baton Rouge side was a fixed location since the service started in 2016, the specific dock on the New Orleans side of the trip can vary. Also, while the Port currently has a dedicated vessel for its COB service, that hasn't always been the case. At the beginning of the service launch, they utilized a charter company and the vessel varied depending on what was provided by the charter company each week.

The Port and Seacorp AMH indicated a willingness to compile and provide the specific information needed to enable the use of the AISAP Tool, but the timeline that was offered did not fall within the needed timeline for incorporation into this thesis. In addition, the use of E&C data is not an option in this case since Jones Act vessel movements are not captured by that data set. Therefore, another approach to evaluating the impact of the COB intervention was explored.

There are several commonly used trend identification techniques (i.e. MK test and SR test), but the validity of those techniques are based on sets of restrictive assumptions. However, a trend analysis technique developed by Zekai Sen called Innovative Trend Analysis (ITA) avoids all of those restrictive assumptions and therefore avoids requiring intimate knowledge of

statistical theory. The only requirements is that you have equivalent time periods of before and after data and that the data is homogeneous [38]. While it was developed for evaluating time series-based hydrologic data, a literature search did not yield any instances where it had been used for transportation applications as of yet.

In short, Sen's ITA technique plots before and after data with equal lengths of time at equal intervals in ascending (or descending) order. The data from the first half of the time period is plotted against the data from the second half of the time period. This representation allows the data to be compared to the 1:1 line to identify the presence (or not) of a trend and its direction, that is, increasing or decreasing. Figure 28 demonstrates what the results would look like from annual flows of a river for 25 years before 1979 and 25 years after 1978 [38]. In this case, the plot shows that during low flow times, an increasing trend is present while during medium and high flows, no trend and a decreasing trend is present, respectively.

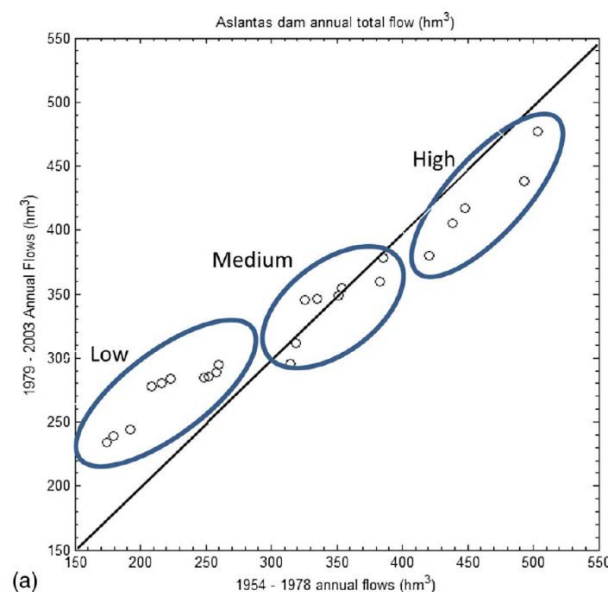


Figure 28. Example ITA plot

The main reason this approach was chosen for this thesis is that it does not require knowledge or information of any specific COB movements. It only requires knowing when the COB service began – June 2016⁸. Also, choosing an appropriate time interval (i.e. annual, monthly, weekly, daily) and the number of periods before and after (must be identical) are the only decisions required.

A full year of NPMRDS data is available going back to 2012, which would only result in four data points if annual data was used. If monthly data was used, in order to protect the homogeneity of the data, the same month(s) would have to be evaluated before and after to protect against possible variations in the data attributable to seasonal traffic patterns. Therefore, using monthly data would also only result in four data points. Daily data provides the most number of potential data points, but is also sensitive to daily variations in sources of congestion due to traffic events like vehicle crashes which threatens the homogeneity of the data. Weekly data, in this case, seems to offer a nice mix of available number of time periods (weeks) before and after June 2016 and data smoothing (multiple days) to minimize the impact a single (non-routine) event might have on the data.

There are 22 full weeks of data available each year prior to June. The same 22 weeks period before and after June 2016 was evaluated using the ITA technique. Therefore, the 22-week period represents January through May of both 2016 and 2017. While the number of weeks could be expanded by continuing backwards into 2015, January 1, 2016 is the earliest included in the analysis because of the differences in the way the NPMRDS data was collected prior to 2016.

⁸ <https://www.benzinga.com/news/19/11/14863376/plastic-resin-exports-drive-growth-for-container-on-barge-service>

Pre-2016 NPMRDS data was collected as a spot speed, whereas post-2015 data was collected as a segment speed. This subtle difference can have a large impact on analyses that stretch across both time periods. Therefore, to avoid that conflict, only post 2015 data was used.

Figure 13 showed that the severity and the length of the congested periods are similar on Mondays – Thursdays and different on Friday – Sunday. Therefore, the data used in the ITA only includes Monday – Thursday to again protect its homogeneity.

Sen used hydrological flow rates to prove and illustrate his ITA methodology. In an attempt for consistency with Sen's approach, it would be ideal to use vehicle flow rates in this application of ITA. The HCM shows that vehicle flow rates can be directly correlated to vehicle speeds at different levels of service [37]. Therefore, the rate of speed provided by the NPMRDS was utilized in the analysis as a proxy for vehicle flows.

Figure 29 and Figure 30, show the results of applying the ITA methodology to a sample TMC segment from sub-corridors A – C and D – F, respectively. There are three possible trend that can be characterized with ITA plots – increasing, decreasing, and no trend. All three trends appear in multiple locations on Figure 29 and Figure 30. An example of each trend is circled in Figure 29. A decreasing trend is shown in the AM peak period of section A, which means that for the low and medium speeds (15 – 40 mph), they trended lower (or worse) in the January to May period after launching the COB service. The AM peak period of section B demonstrates an example of when there is neither an increasing nor decreasing trend present, which means that for the medium speeds (30 – 45 mph), there is no appreciable difference speeds when comparing the January to May period before and after launching the COB service.

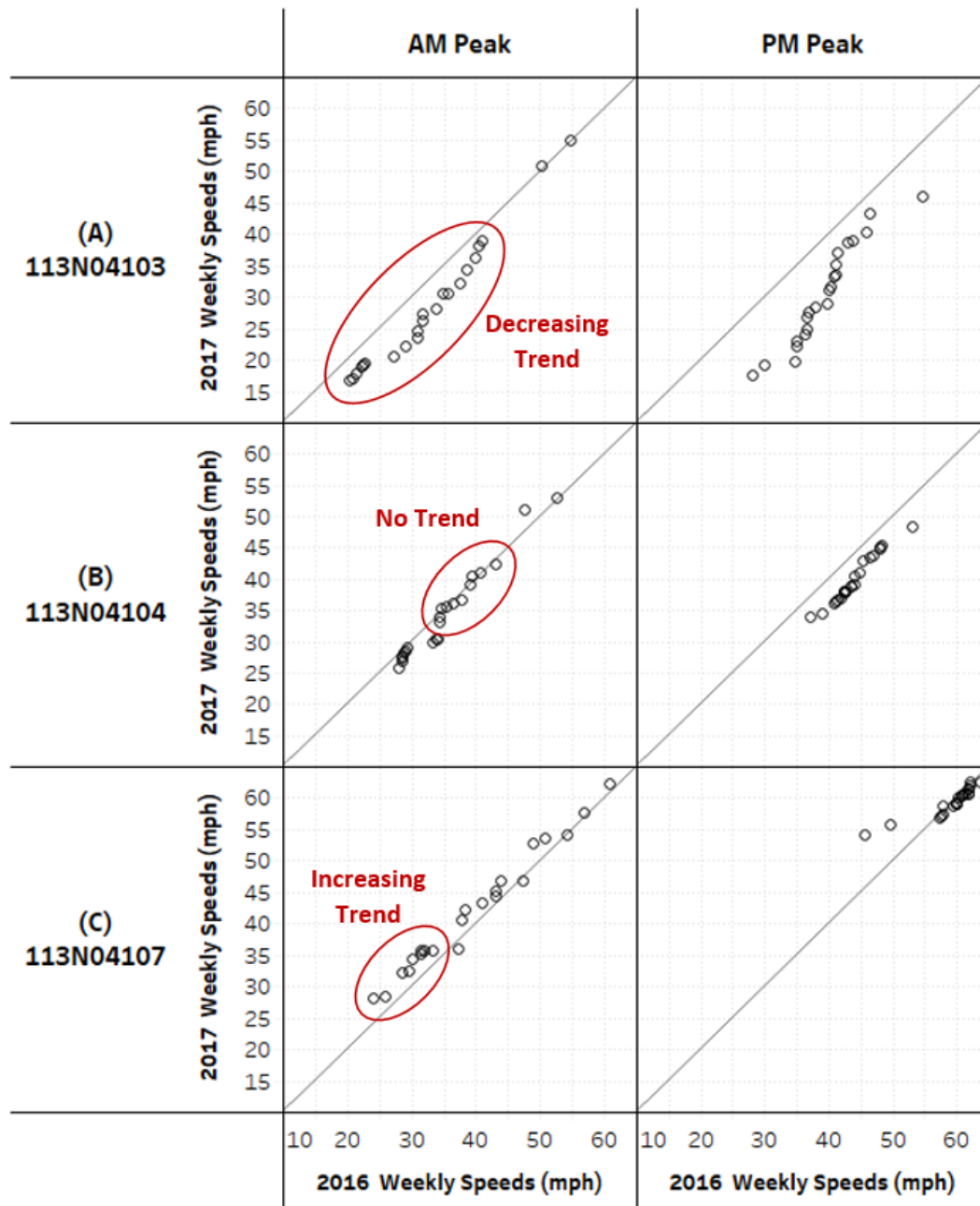


Figure 29. ITA plots of sample TMC segments from sections A - C

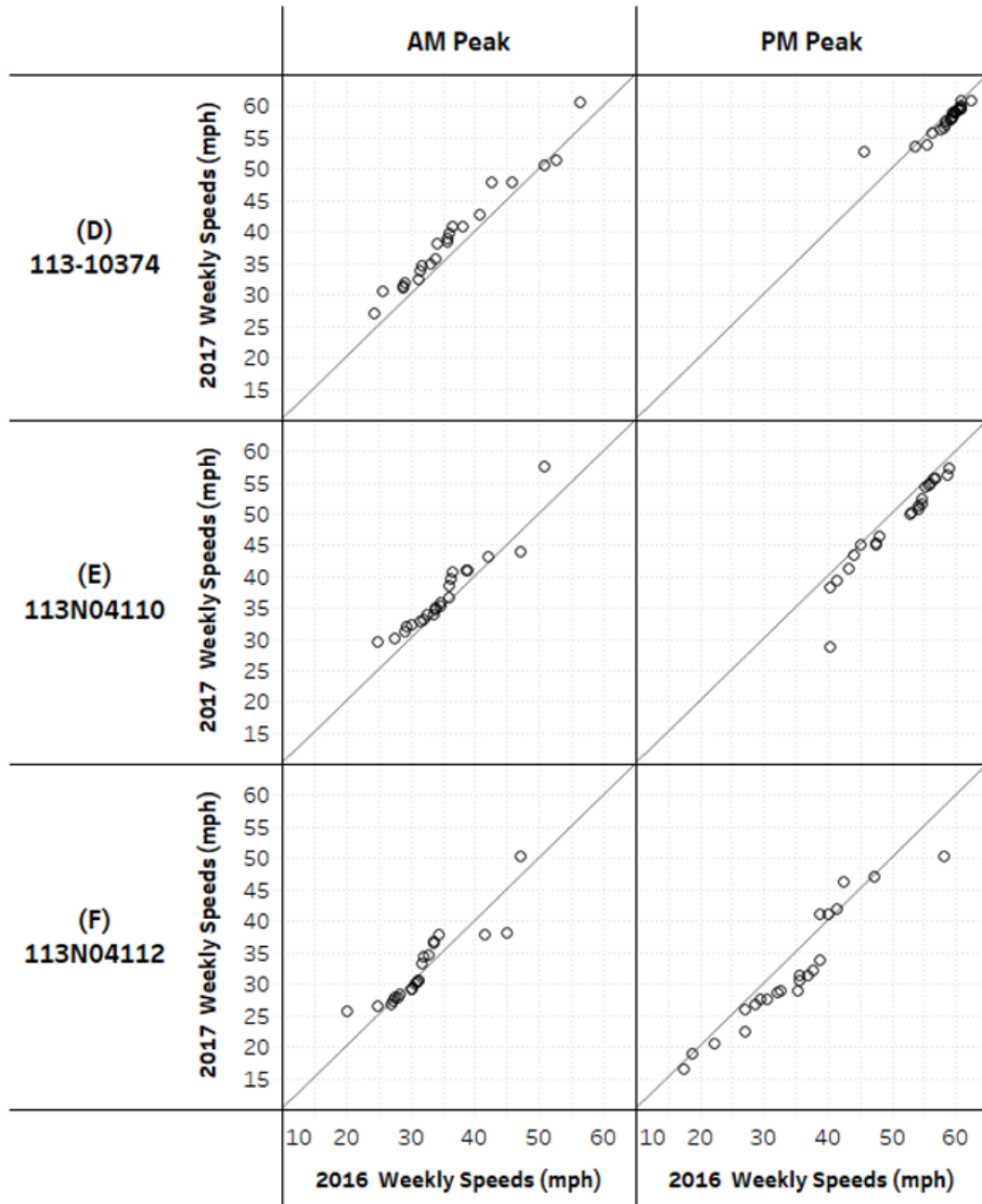


Figure 30. ITA plots of sample TMC segments from sections D - F

With the exception of section A, speeds either increased or showed no trend for the period after the introduction of COB when compared to the same period before the introduction of COB. This would suggest that COB has had a positive effect on congestion. However, to verify that would require an evaluation of overall traffic volume trends along that corridor during that

same period. Unfortunately, the permanent count station in Section A could not provide the data to perform that validation as shown Figure 31.

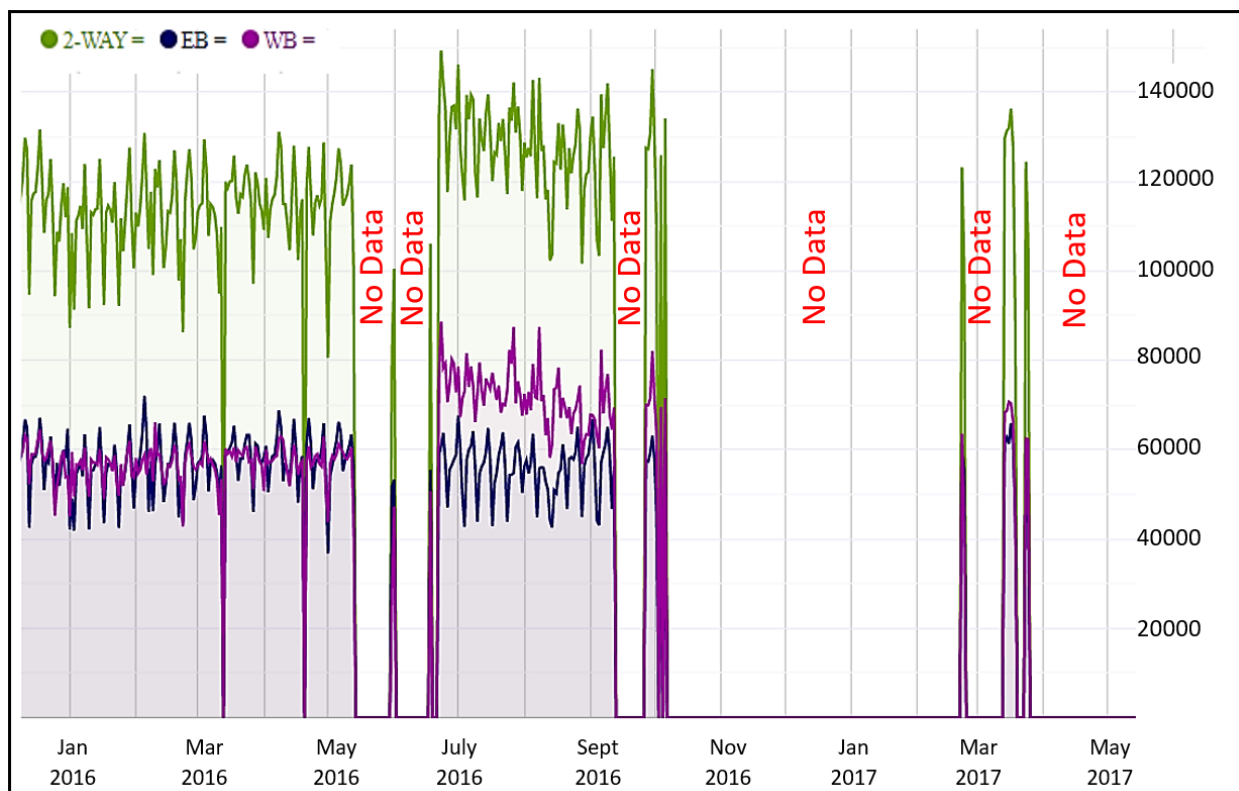


Figure 31. January 2016 - May 2017 traffic volumes on I-10⁹

Figure 31 is a plot of traffic volumes from the permanent count station on I-10. As you can see from the figure, there are sizable chunks of data missing from the record. January 2016 through May 2016 has nearly complete coverage, but January 2017 through May 2017 has minimal coverage. This means that a comparison of traffic volumes between the before and after COB introduction cannot be conducted, and thus, the ITA result cannot be attributed to the COB service (or any other source, for that matter).

⁹ This plot was provided by DOTD and is an output from their traffic data management software called MS2.

Chapter 5: Implications for the Literature

There are underlying assumptions that were revealed by the selection and use of New Orleans as a case study. Perhaps the most important and impactful of these was the assumption that either there was enough containers being handled by Port NOLA on a daily basis or that enough of those containers actually reached the study corridor on a daily basis to have any sort of impact on interstate congestion. Based on the results of the analyses, those assumptions appear to be unfounded. Even if the first assumption was true, determining what portion of the containers reached the study corridor is challenging. While PIERS data could give a record of individual container movements on and off the vessel, it does not provide any information related to the mode (i.e. truck, rail, or barge) that each container arrived or departed on. It also does not provide specific information on where it's going or came from. Some containers may stay local and never touch the interstate system and some containers leave or enter the city via the interstate system from all directions.

To address the unknown mode share and route share issues, a massive field data collection effort would have been required which was beyond the scope of this thesis. However, to verify the conclusion that these underlying assumptions were false for New Orleans, a limited amount of data was collected from a publically accessible DOTD traffic camera located near DOTD's permanent count station in sub-corridor A. Using a free, open-source, cross-platform multimedia player called VLC, the URL-based video stream was recorded during various AM and PM congested periods. The camera used in this data collection was located on I-10 near Williams Boulevard in Kenner. An example of the camera view is shown in Figure 32. The figure also shows

the location of the DOTD permanent count station, the location of I-10 eastbound, and the location of the William Blvd. off-ramp.

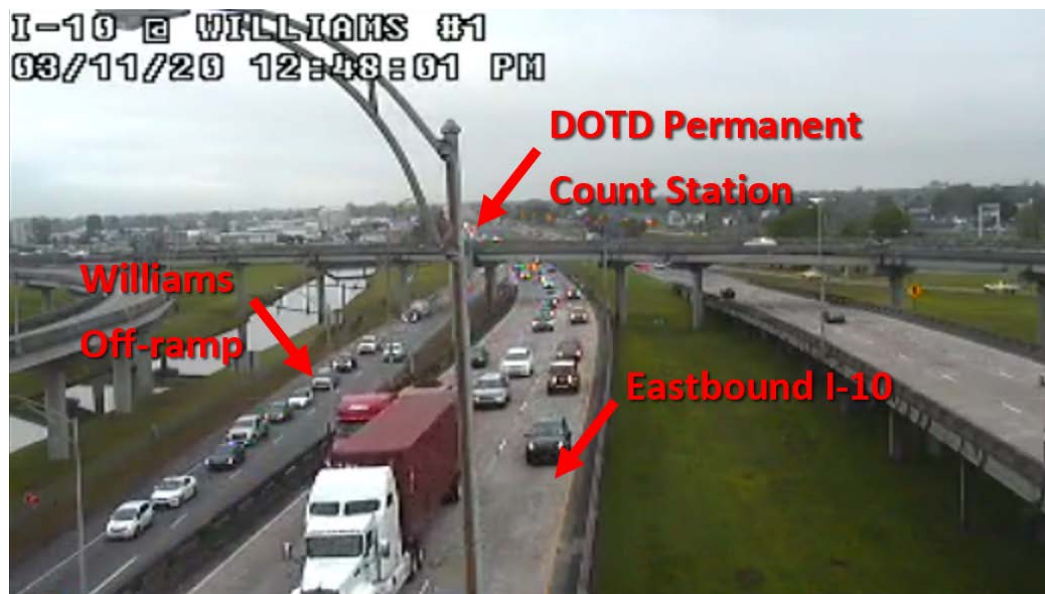


Figure 32. Example view of from DOTD traffic camera on I-10 at Williams Blvd.

Container vehicles, or CVs (see Chapter 2 for full description) were manually counted on an hourly basis for both the 3 lanes of eastbound I-10 and the two lanes of the Williams Blvd. off-ramp since the Williams off-ramp is located just after vehicles pass the DOTD permanent count station. The CV counts were then compared to the classification counts from DOTD's permanent count station. The date, hour, CV count, total vehicle (TV) count, percent of TV from CV, combination truck (CT) count, and percentage of CT from CV are shown in Table 3 for the AM and PM time periods.

Table 3. Sample of Container Truck Traffic on Sub-corridor A

AM							PM						
Date	Hour	CV	TV	% of TV	Total CT	% of CT	Date	Hour	CV	TV	% of TV	Total CT	% of CT
12/6/19	6-7	35	4378	0.8%	138	25.4%	1/22/20	3-4	19	4279	0.4%	83	22.9%
12/6/19	7-8	47	4194	1.1%	135	34.8%	1/22/20	4-5	10	4561	0.2%	54	18.5%
12/6/19	8-9	21	4206	0.5%	122	17.2%	1/22/20	5-6	4	4663	0.1%	53	7.5%
12/6/19	9-10	46	4313	1.1%	142	32.4%	1/22/20	6-7	7	4024	0.2%	34	20.6%
1/27/20	9-10	26	4035	0.6%	129	20.2%	1/27/20	3-4	26	4106	0.6%	96	27.1%
1/28/20	9-10	34	3946	0.9%	134	25.4%	1/27/20	4-5	7	4533	0.2%	43	16.3%
2/6/20	8-9	26	4053	0.6%	117	22.2%	1/27/20	5-6	6	4493	0.1%	40	15.0%
2/6/20	9-10	38	4277	0.9%	155	24.5%	1/27/20	6-7	9	3564	0.3%	52	17.3%
3/5/20	7-8	30	4000	0.8%	168	17.9%	1/28/20	3-4	20	4136	0.5%	69	29.0%
3/5/20	9-10	51	4280	1.2%	148	34.5%	1/28/20	4-5	19	4419	0.4%	69	27.5%
3/6/20	6-7	27	4362	0.6%	173	15.6%	1/28/20	5-6	6	4510	0.1%	45	13.3%
3/6/20	7-8	23	4057	0.6%	189	12.2%	1/28/20	6-7	10	3760	0.3%	36	27.8%
3/11/20	7-8	30	4035	0.7%	151	19.9%	1/29/20	3-4	25	4290	0.6%	72	34.7%
3/11/20	8-9	34	4033	0.8%	1126	3.0%	1/29/20	4-5	15	4417	0.3%	45	33.3%
3/11/20	9-10	47	4026	1.2%	137	34.3%	1/29/20	5-6	3	4545	0.1%	42	7.1%
3/12/20	7-8	29	4148	0.7%	99	29.3%	1/29/20	6-7	3	3669	0.1%	31	9.7%
3/12/20	8-9	21	4176	0.5%	112	18.8%	2/6/20	3-4	21	4418	0.5%	63	33.3%
3/12/20	9-10	25	4106	0.6%	142	17.6%	2/6/20	4-5	6	4797	0.1%	49	12.2%
---	---	---	---	---	---	---	2/6/20	5-6	7	4821	0.1%	71	9.9%
---	---	---	---	---	---	---	2/6/20	6-7	7	3991	0.2%	57	12.3%
AM Average:		33	4146	0.8%	195	22.5%	PM Average:		12	4300	0.3%	55.2	19.8%

Thirty-eight hours of video was successfully recorded and analyzed on an hourly basis. For the 18 hours of AM data collected, on average, CVs made up about 0.8% of the total vehicles and 22.5% of the CTs. For the 20 hours of PM data collected, on average, CVs made up about 0.3% of the total vehicles and 19.8% of the CTs. While this is only a small sample of data, the idea that the study corridor does not have enough container vehicle traffic to produce a detectable relationship between vessel presence/size and interstate congestion seems plausible since less than 1% of total vehicle traffic comes from container vehicles.

Another underlying assumption revealed by exploring this thesis is that for the techniques to be utilized effectively without acquiring significantly more complementary data, the corridor being evaluated should have non-metered access to the interstate. That is, there should be minimal or no infrastructure/operations features impeding the flow of container trucks between the port and the study corridor. The assumption seems to hold true for the approach to the Eastbound direction of the case study corridor in this thesis since there are no infrastructure-related impediments immediately prior to entering the corridor, but when considering the effect of spreading truck arrival times throughout the day by utilization of a truck scheduling system, the assumption is actually false. The approach to the Westbound direction of I10 has the same operational restrictions resulting from truck scheduling, but it also has multiple infrastructure components in play that result in the entrance of container trucks to the corridor being metered prior to actually entering the corridor. For example, as a truck leaves the port via the Clarence Henry Truckway, it must traverse four separate traffic signals and a set of ramp meters. The metering effect of these infrastructure and operational components coupled with the fact that there are a finite number of truck appointments available each day means that for any given hour, there is likely a maximum container truck flow rate that has no relation to fluctuations in vessel presence/size or daily fluctuations in the number of containers handled by a port.

A third assumption built in to the case study in this thesis is that vessel size can serve as an indicator of the volume of containers being handled by a port. To put it simply, the assumption is that big vessels result in the port handling more containers when compared to small vessels. Analyzing the one month of PIERS data made available by IHS Markits reveals that this assumption is not necessarily a safe one for Port NOLA. Figure 33 shows a plot of the TEUs

handled by Port NOLA in October 2019 from each vessel of each day. The TEU count represents the combined import and export TEUs. Each circle represents a port call and the size of the circle represents the size/capacity of the vessel in NRT.

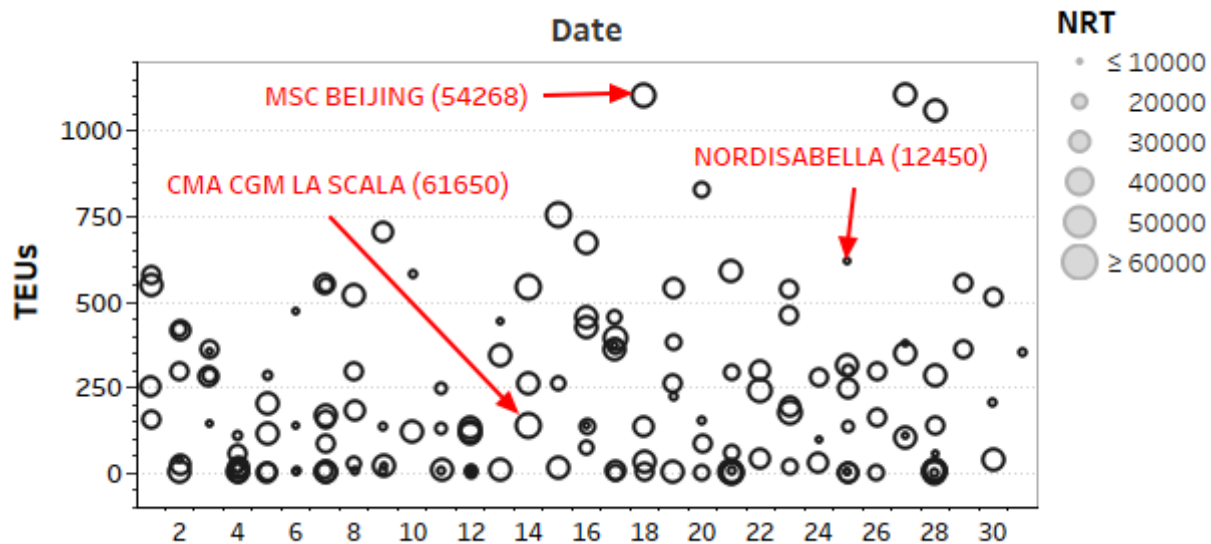


Figure 33. NRT vs. TEUs for October 2019

If the assumption that vessel size is an indicator of the magnitude of TEU activity generated by that vessel during a port call, then you would expect to see the size of the circles increasing as you move from the bottom of the plot to the top. Visual inspection of Figure 33 reveals no such trend. In fact, different size circles are scattered throughout the plot. Three circles (2 large, one small) are called out in the figure to further illustrate the point that the assumption is false for Port NOLA. The MSC Beijing is a fairly large vessel at 54,268 NRT and Port NOLA handled 1101 TEUs on October 18th, 2019 and was also one of the largest quantities handled that month. However, Port NOLA hosted an even larger vessel called the CMA CGM La Scala (61,650 NRT) on October 14th, 2019, but its port call only resulted in the handling of 137 TEUs. A third vessel, the much smaller Nordisabella (12,450 NRT), resulted in Port NOLA handling

four and a half times more TEUs (617) than the much larger vessel, the CMA CGN La Scala. There are countless other examples of this assumption-busting data throughout the plot.

The failure of the case study in this thesis to meet the three underlying assumptions detailed above does not necessarily mean that that the approach explored in this thesis is not a feasible approach. It simply means that the approach is not necessarily appropriate for Port NOLA and the selected corridor. In fact, the use of this approach on this case study is what revealed those three assumptions and the importance of them.

Chapter 6: Conclusions and Future Work

Conclusions

The increasing trend of traffic congestion in the US along with increased competition for limited funding means that public officials must ensure that transportation investment decisions are based on valid assumptions and/or real data. This thesis presented research based on real-world data that speaks to the validity of some assumptions and perceptions as it relates to the relationship that cargo vessel movements and characteristics have on corridor congestion in a given port city or region.

The first component of the study involved the exploring the suitability of fusing vehicle probe data with vessel data for contextualizing the multimodal interaction impacts on interstate corridor mobility. The results presented in this study showed that fusing vehicle probe data with vessel data is achievable and appropriate as a means of exploring the relationship between roadway and waterway modes as long as both data sets share common spatial and temporal data elements that are complemented by contextual characteristics.

The second component of the study involved an effort to validate the prevailing assumptions and perceptions related to the impact that cargo vessel size/capacity, the frequency of cargo vessel port calls, and COB service have on corridor congestion in a given port city or region. As it relates to the New Orleans case study, the results suggest that those assumptions may not be valid in New Orleans due to the nature of the operational and infrastructure factors (metering effects) specific to Port NOLA and its surrounding roadways.

Overall, the results showed that, by joining these modally disparate data sets together and analyzing them as one, additional context can be added to the discussion related to

transportation operations and investment decision making through either the confirmation or disproof (as in the New Orleans case study) of assumptions, perceptions, or expected results related to container truck traffic on the interstate system. The approaches employed in the analysis of the conflated data showed that by including vessel data in roadway mobility analyses, the extent (or lack thereof, as in our case study) of the role that vessels play, in terms of their contribution to interstate congestion on a corridor, can be further characterized.

However, the study also revealed that caution should be used when performing analyses based on the conflated data sets. Each of the vessel data sets explored in this study have separate issues that can bring into question the validity of the results associated with analyses seeking to determine the role that port-related traffic might play as it relates to interstate corridor congestion. Those issues are as follows:

- AIS data has the potential to be incomplete depending on how the query is designed or how reliable the underlying AIS messages being logged are. However, this AIS data completeness question could be quantified and potentially mitigated by comparing it to E&C data.
- Since E&C data is based on a daily representation of port calls, its temporal resolution lacks the context that more granular data (like AIS) offers and can result in an over-representation (temporally) of vessel activity.
- E&C data is a curated data set published annually with about a one year lag (2018 data was published in December 2019). This lag restricts E&C data to use for historical analyses that don't include the most recent 12-month period.

- One month of PERS data alone is too narrow of a timeframe for use in interstate corridor congestion analyses. However, this shortfall could be overcome by either: (1) combining PERS data with other data sources (e.g. incident logs, weather, special events, crashes, etc.) to ensure the full picture is painted as it relates to sources of roadway congestion; or (2) by using a larger PERS data set that covers a much longer timeframe (as was possible with AIS, NPMRDS, and E&C) so the effects of other sources of congestion could be negated by the smoothing that can occur with temporally longer data sets.
- While each of the other data sets used in this thesis can be obtained by state DOTs at no additional expense, PERS data is a commercial product and therefore must be purchased from a private vendor. Therefore, using it for a long term analysis could be cost prohibitive.

Despite the issues outlined above, the analysis techniques utilized in the case study showed that vehicle probe data can successfully be fused with various vessel data sources to provide context related to the relationship between vessel movements and vehicle movements. In fact, while the case study was not able to pinpoint any specific cause and effect relationship between vessels and vehicles at Port NOLA and on I-10, the case study analysis was able to successfully identify that there were other sources of congestion at play in New Orleans whose contribution to congestion likely dwarfs that of container vessel-related traffic. That additional context can be a key factor in assessing the impacts of previous transportation investment decisions or in informing future ones.

Future Work

Applying the methodologies in this thesis to other corridors or cities could benefit from additional research that:

- Determines the latency between the time that vessels arrive in port to the time the first container hits the highway and how sensitive the results are to that latency.
- Determines if there is a threshold for CV% that must be met in order to ensure this type of analysis would be worthwhile for a given container port city.
- Determines what role and to what extent existing infrastructure or operations plays in metering the flow of containers truck traffic between the port and the freeway.
- Identifies another port and corridor, whose characteristics agree with the underlying assumptions presented earlier in this Chapter, and further tests the effectiveness and appropriateness of the approach when all underlying assumptions are valid.

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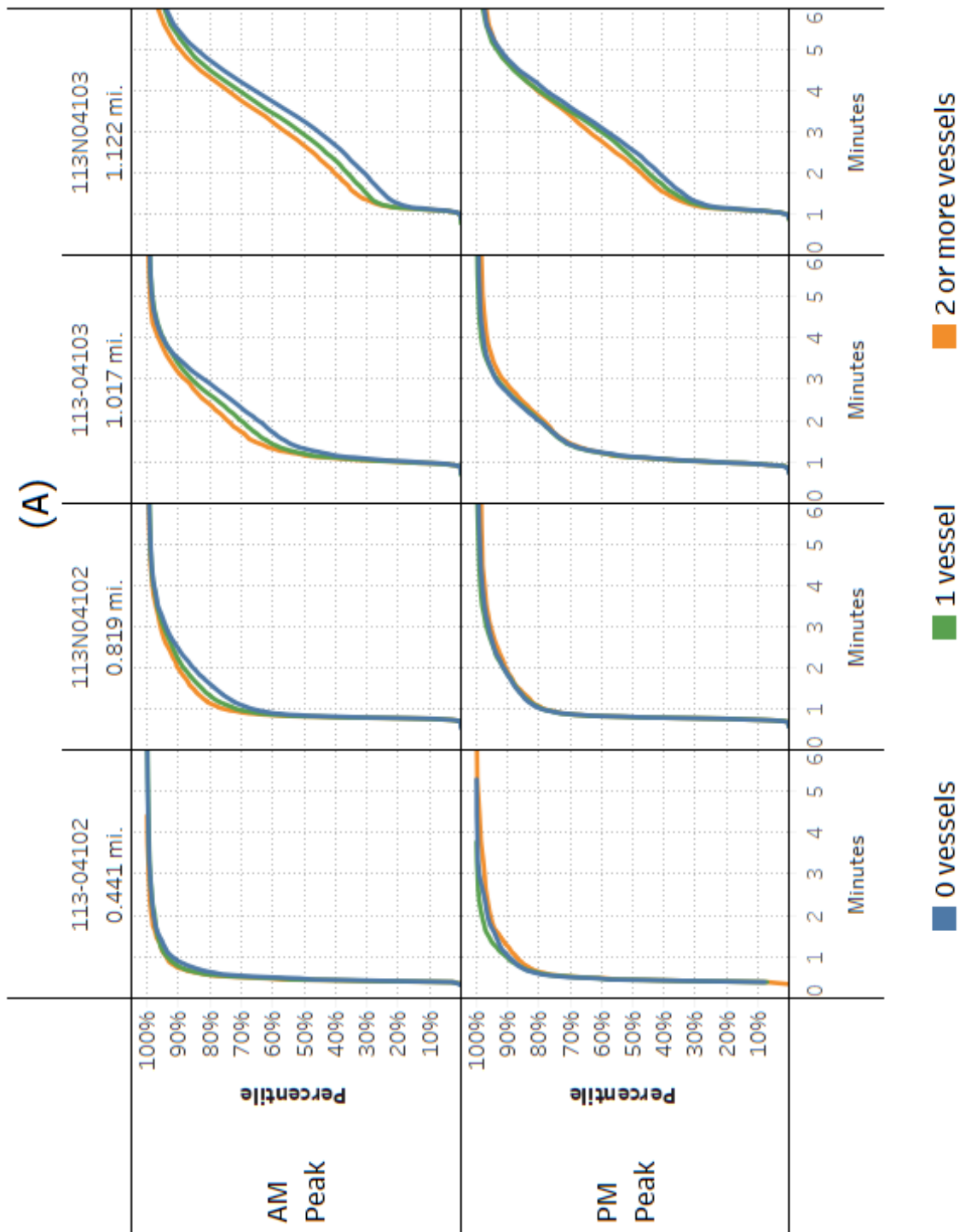
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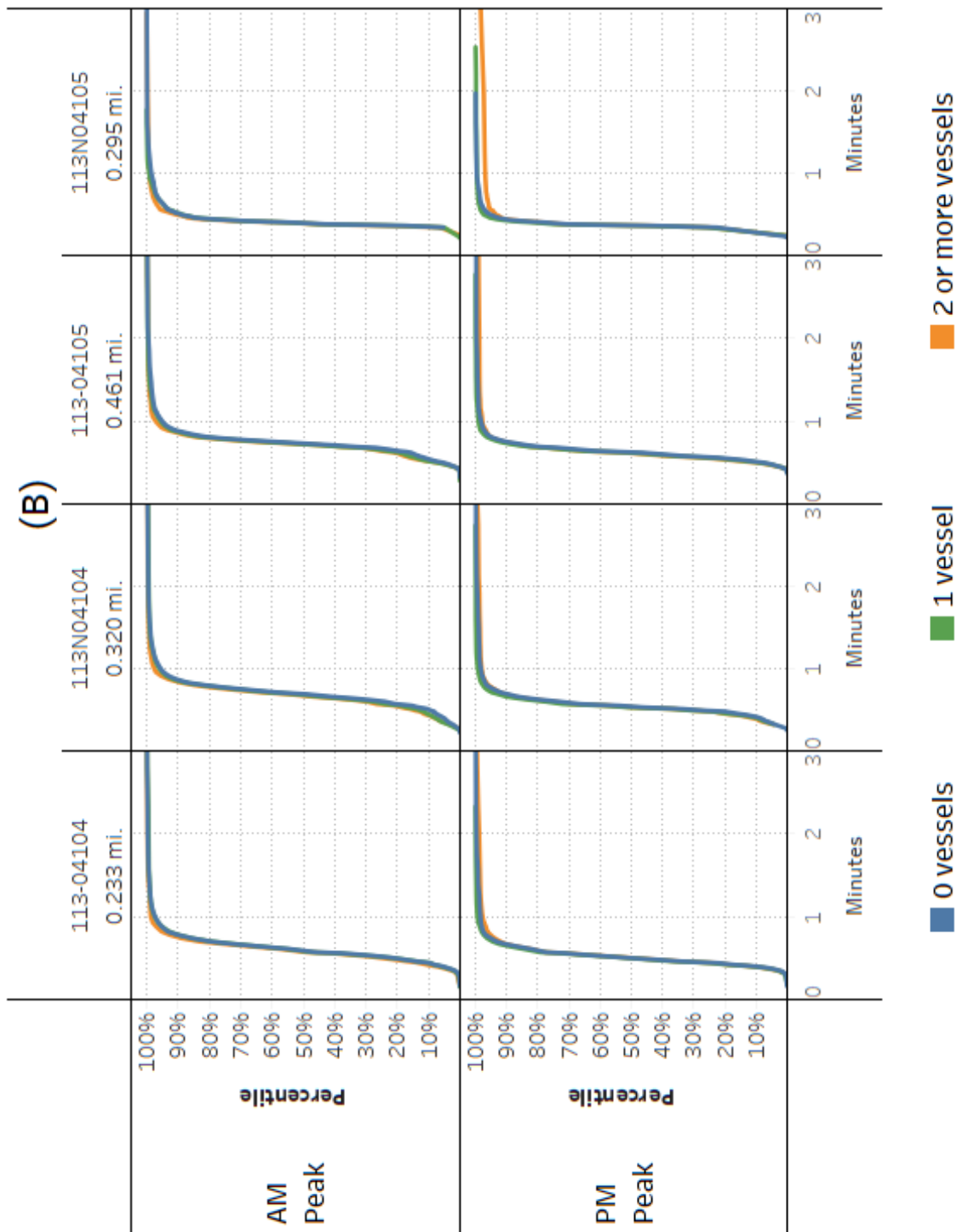
Appendix A. Hourly Traffic Volumes for October 2019

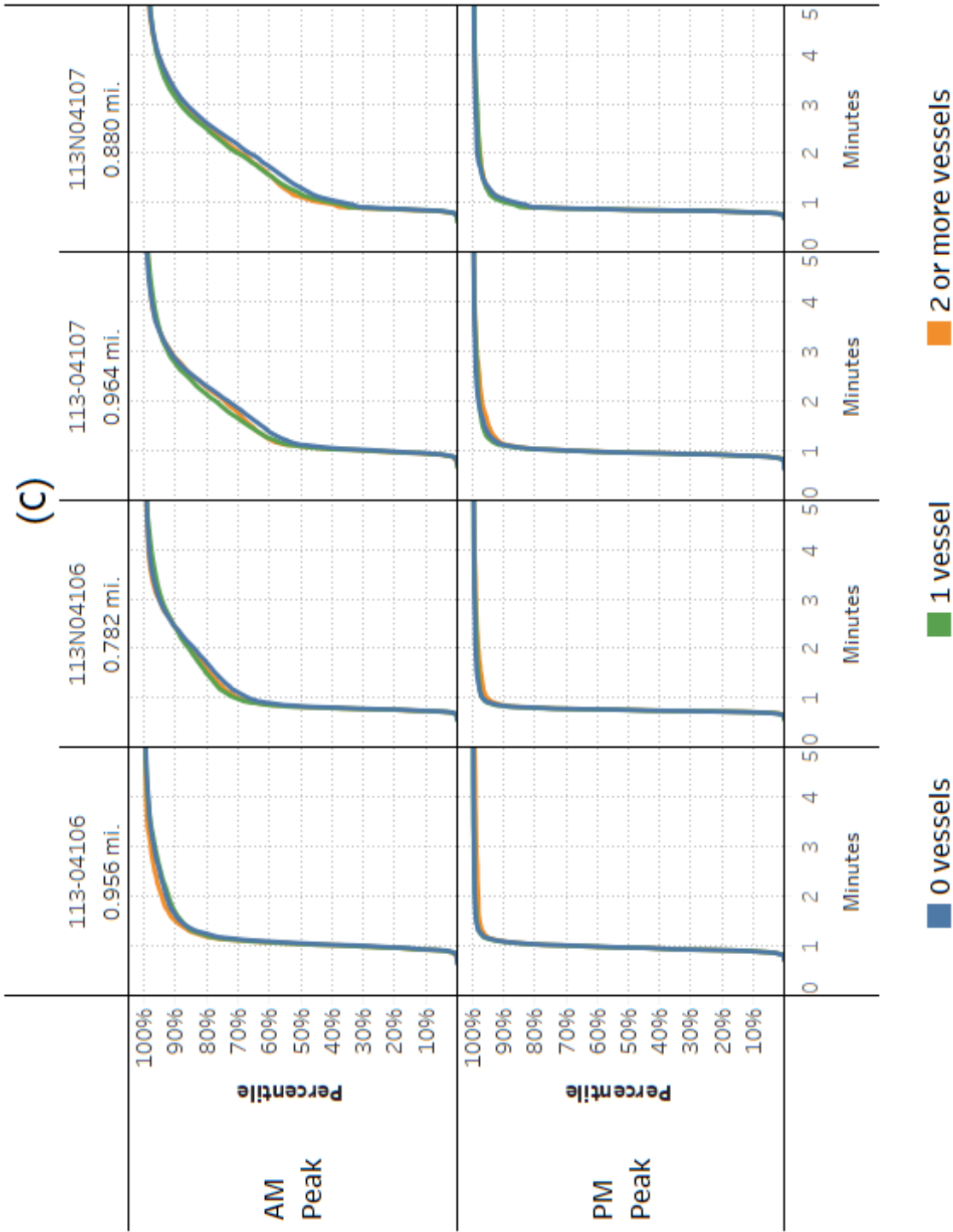
026_EB: Monthly Hourly Volume for October 2019

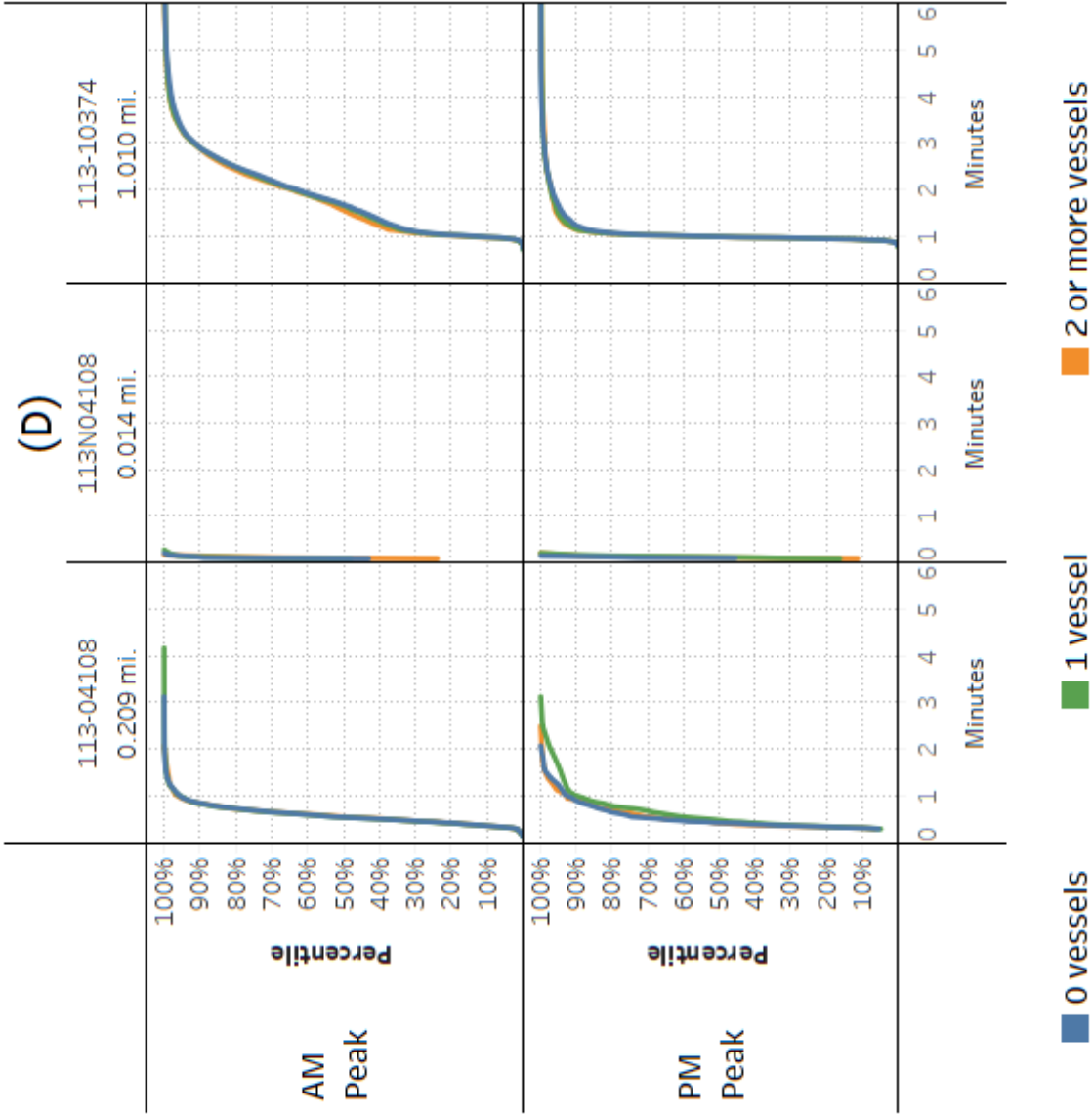
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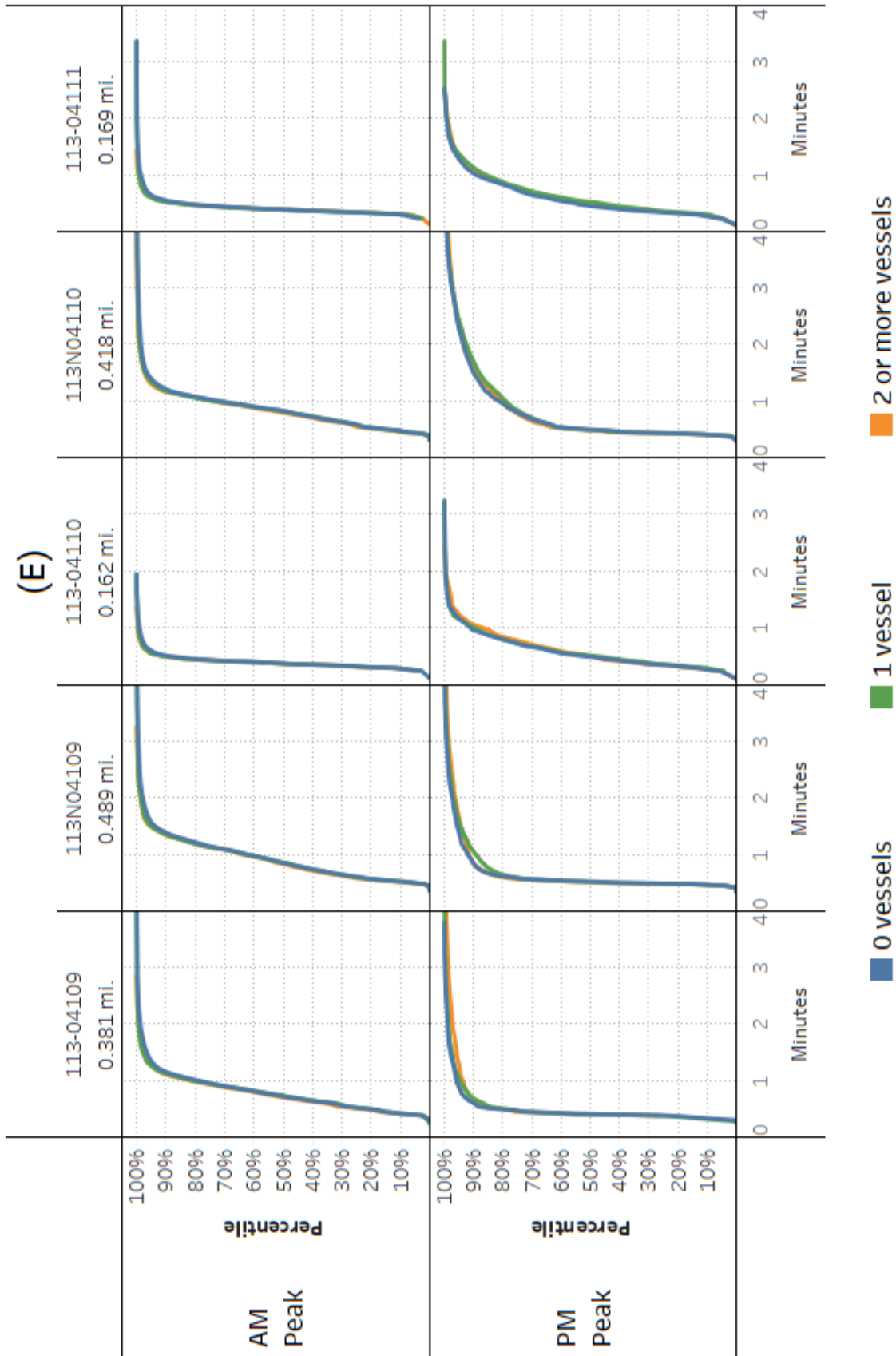
Appendix B. CDF plots Showing Impact of Container Vessel Presence for Each TMC Segment Based on AIS Data

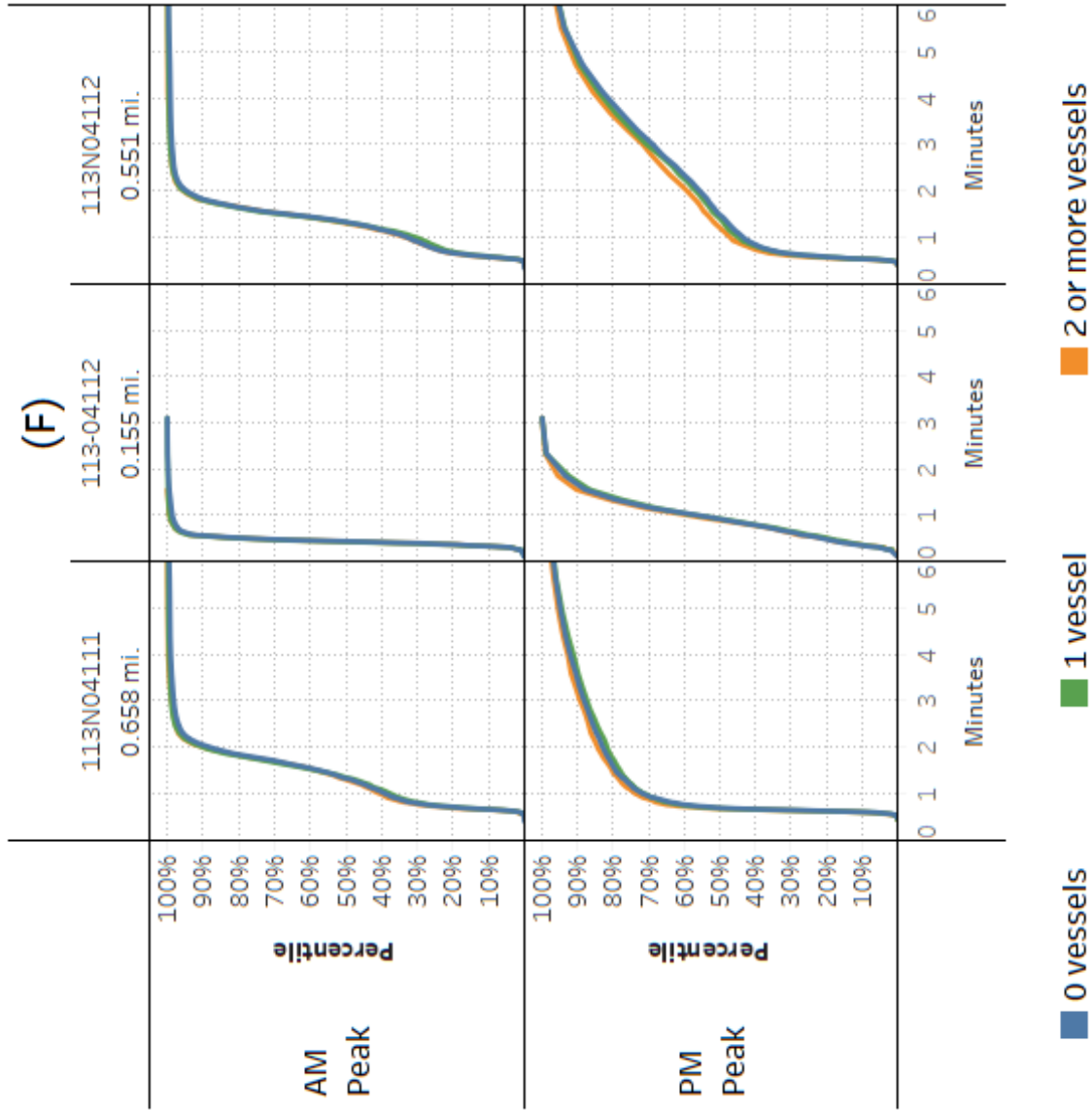




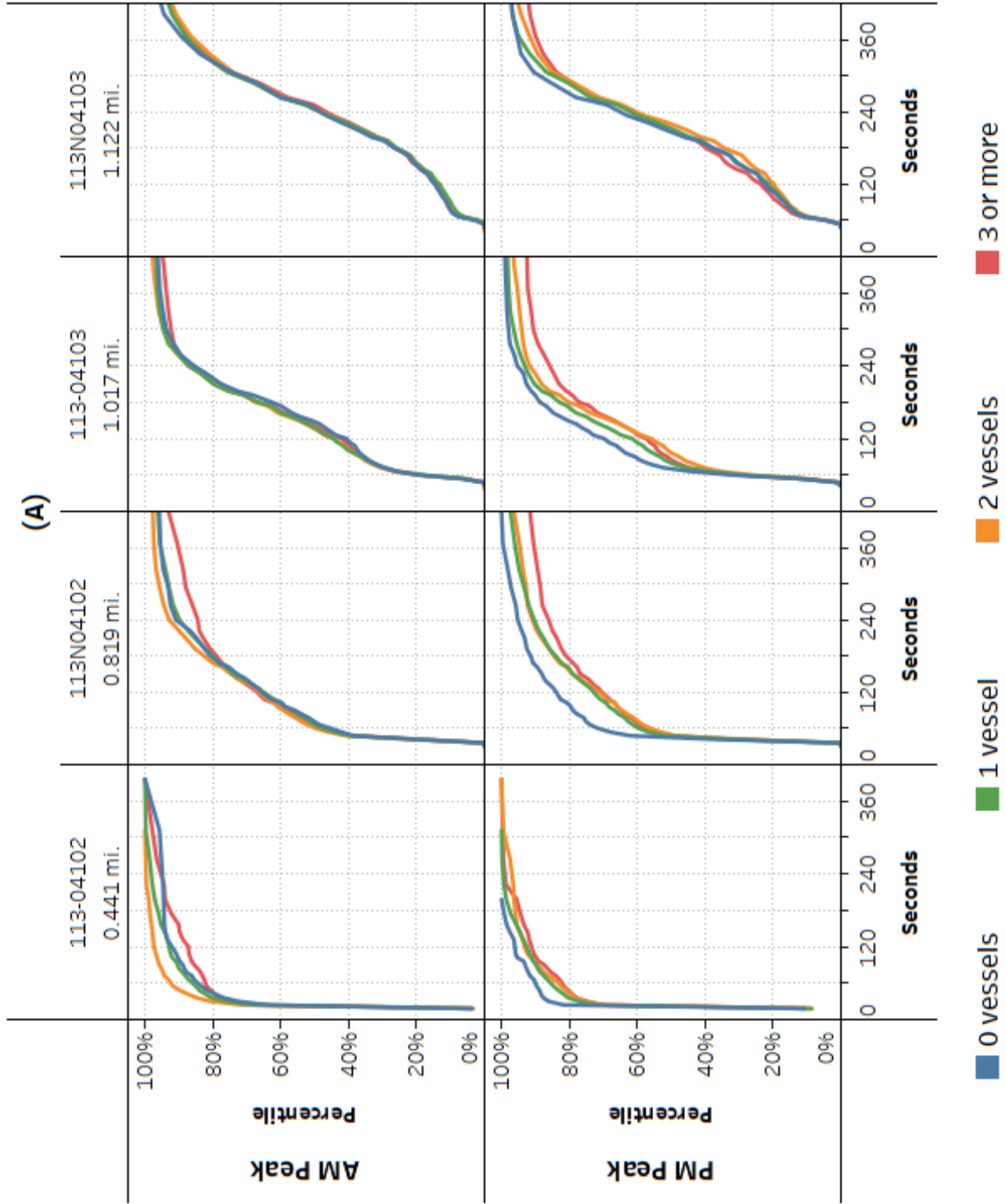


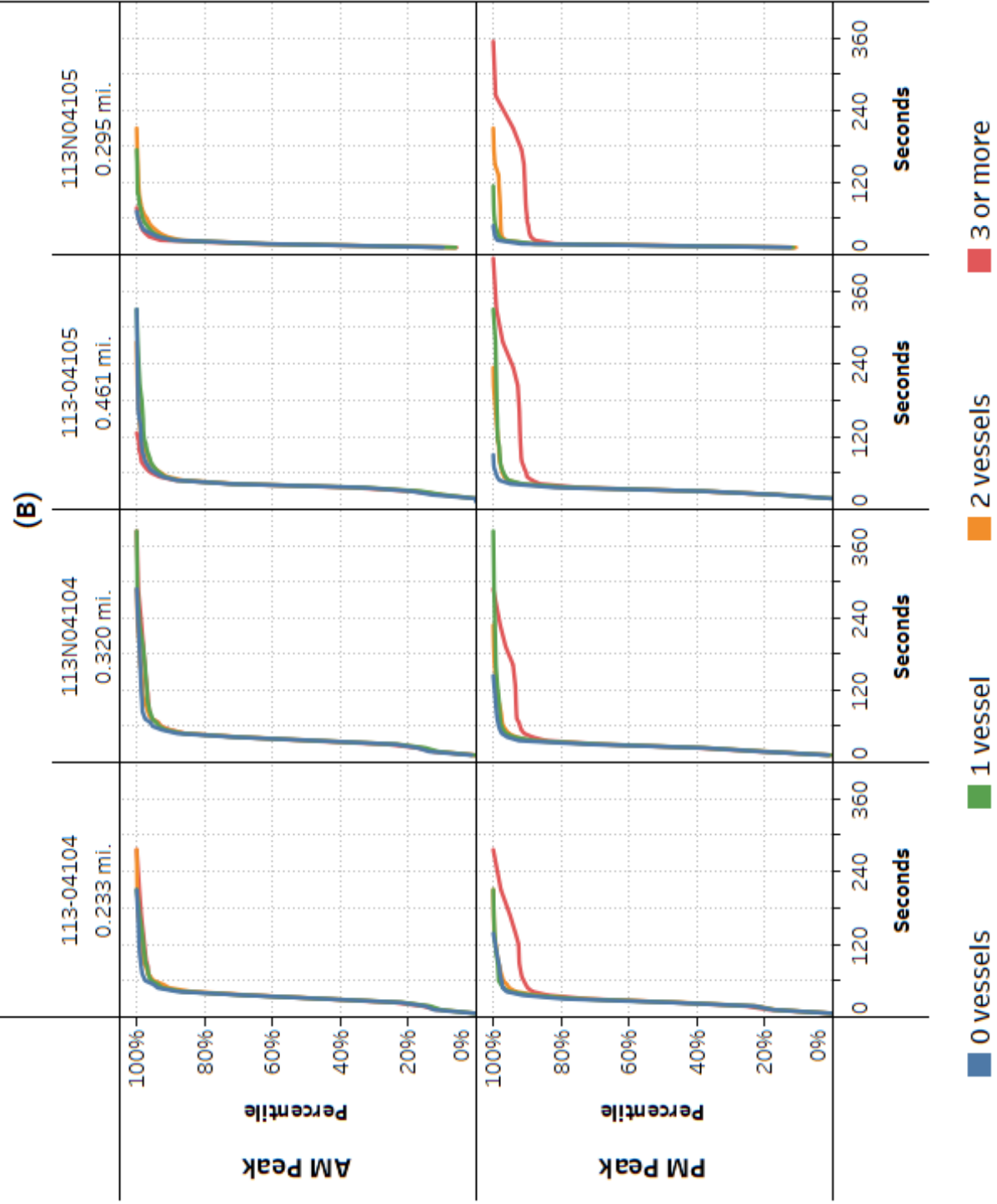


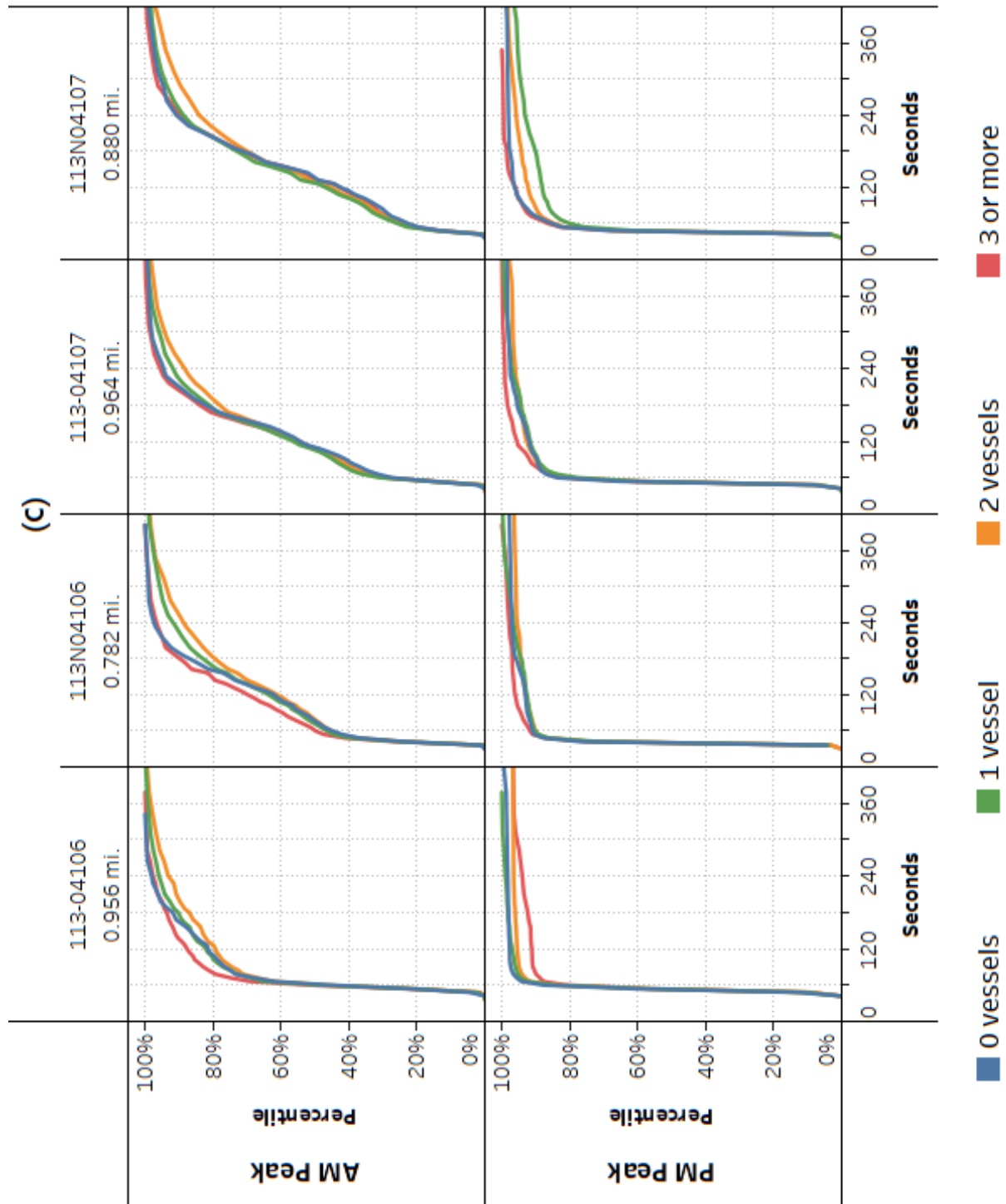


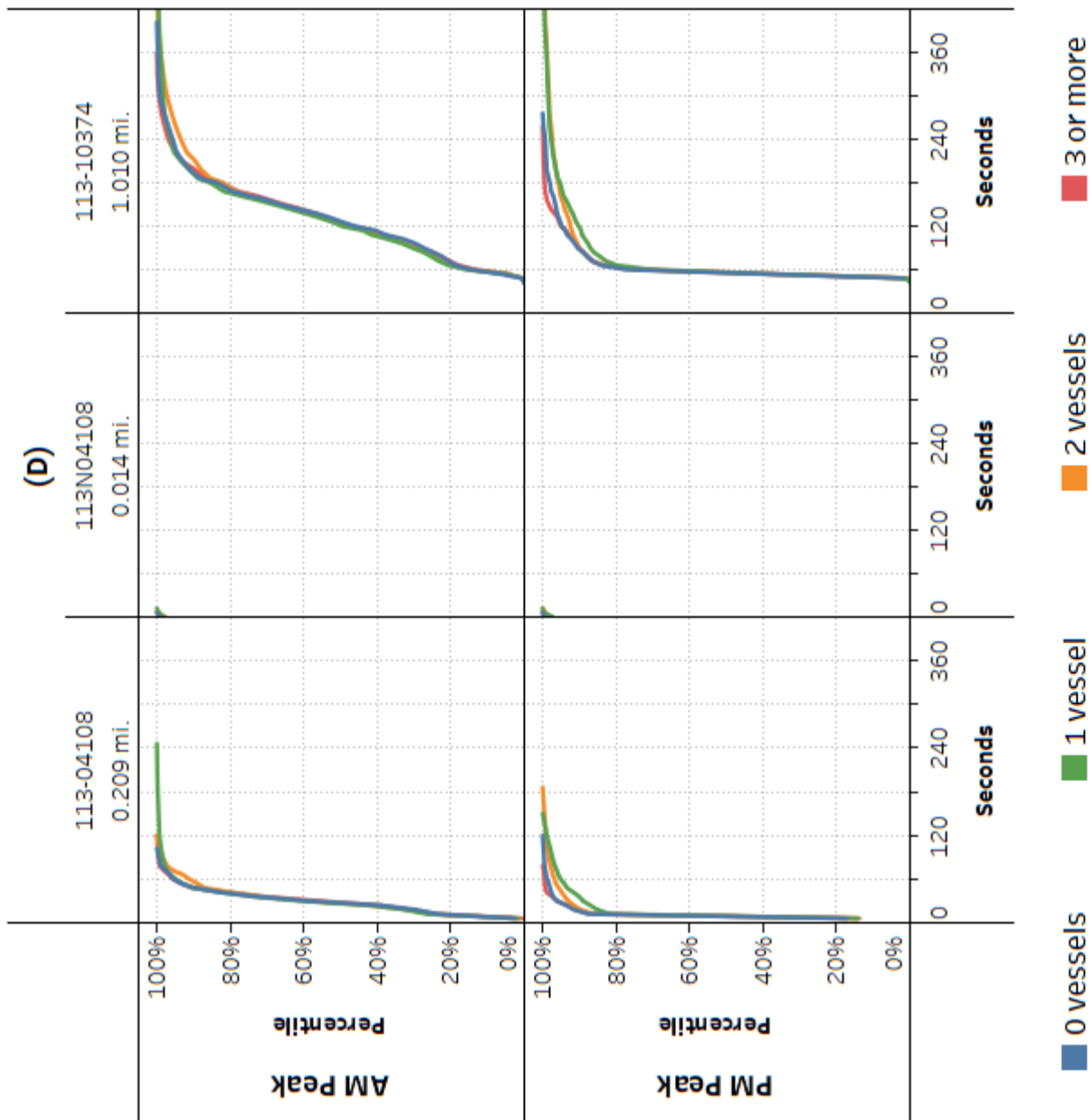


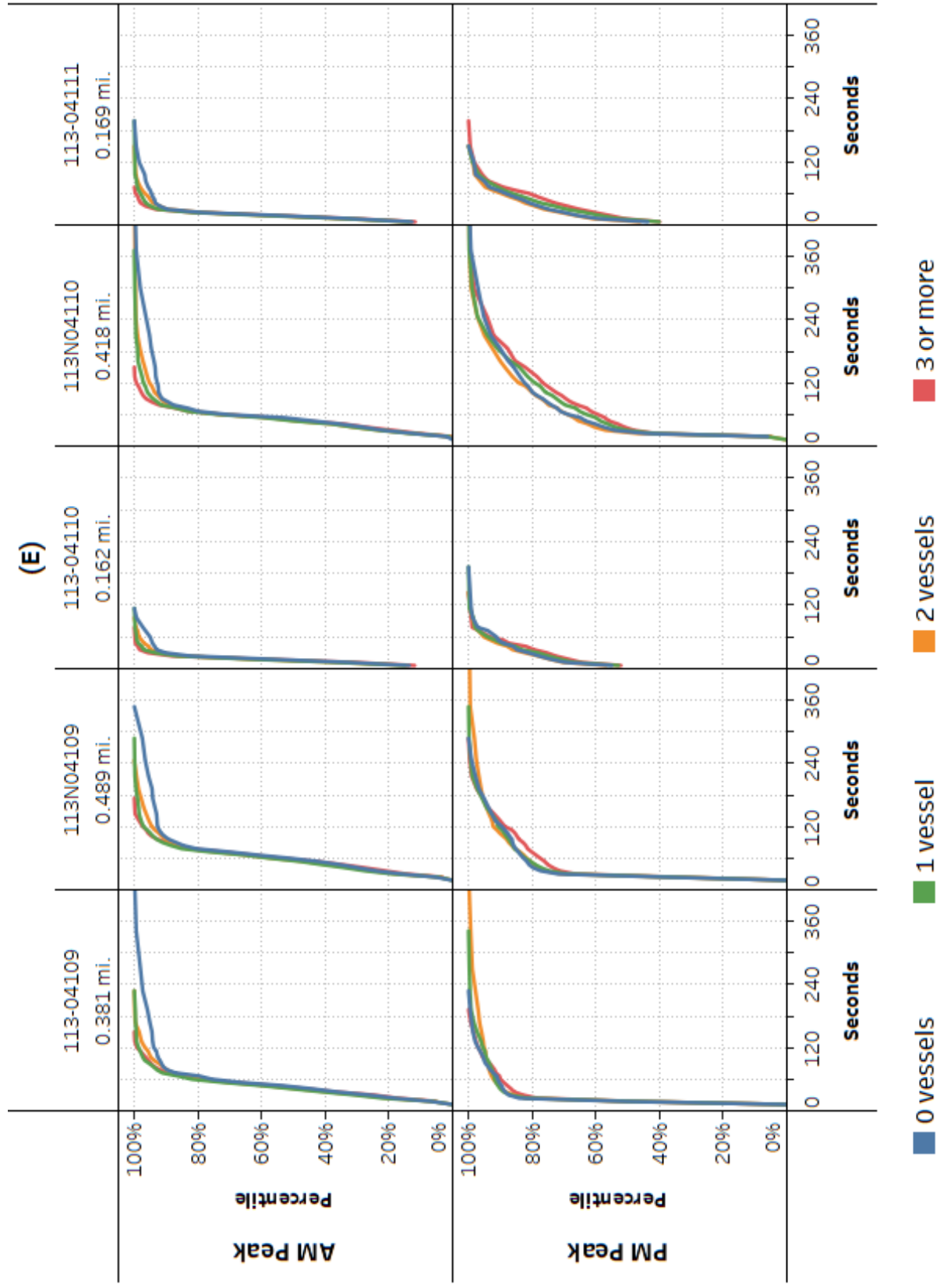
Appendix C. CDF plots Showing Impact of Container Vessel Presence for Each TMC Segment Based on E&C Data

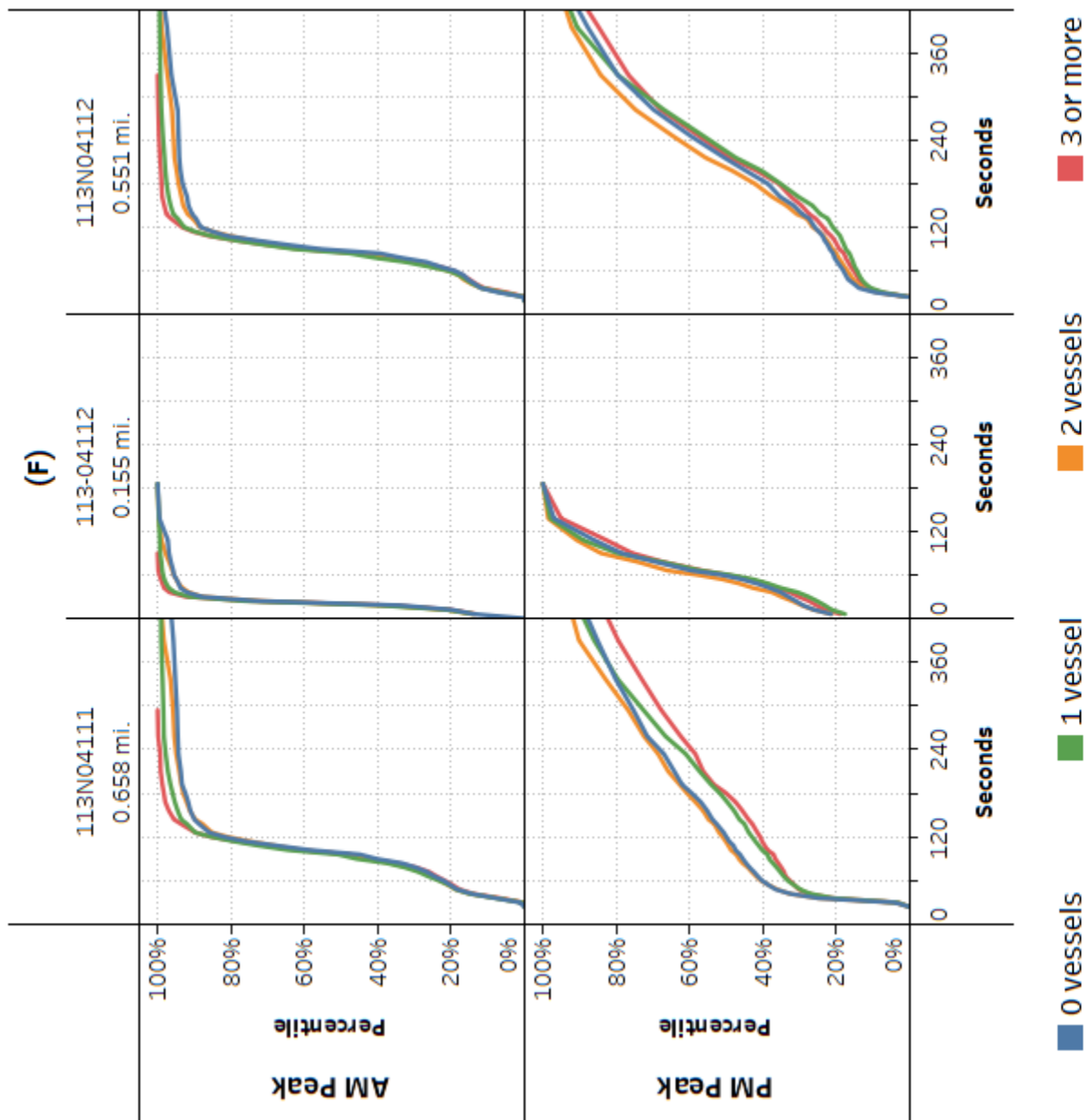




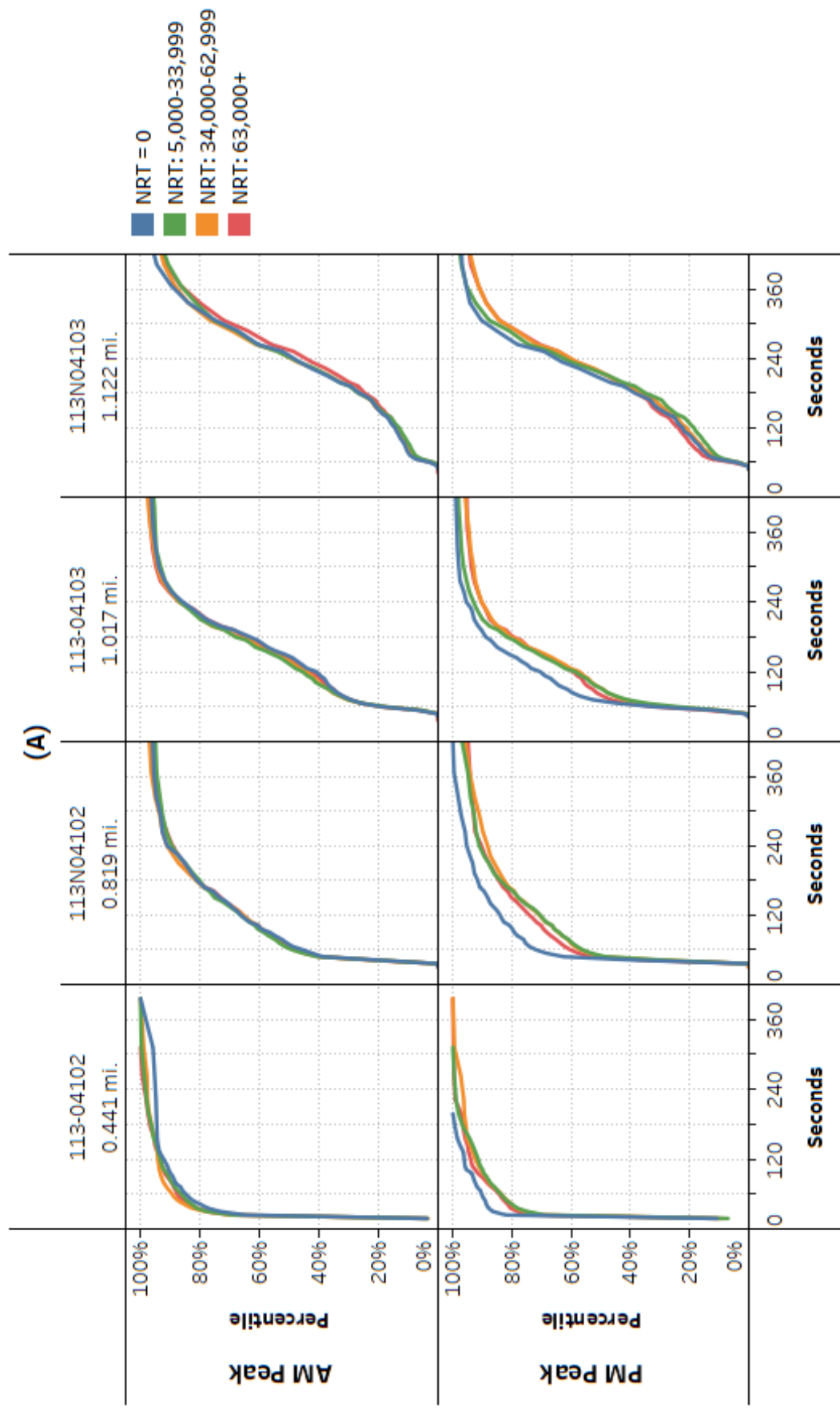


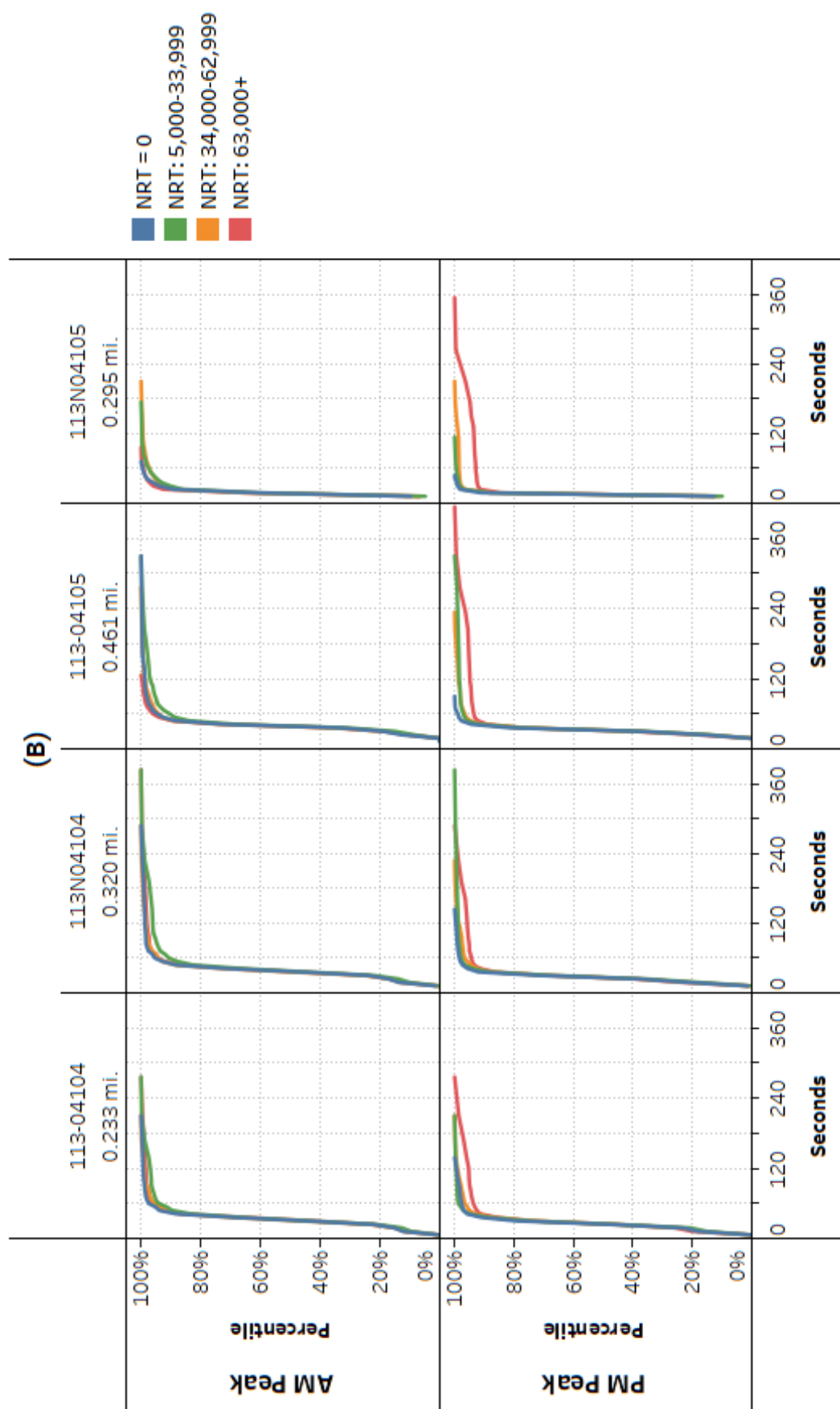


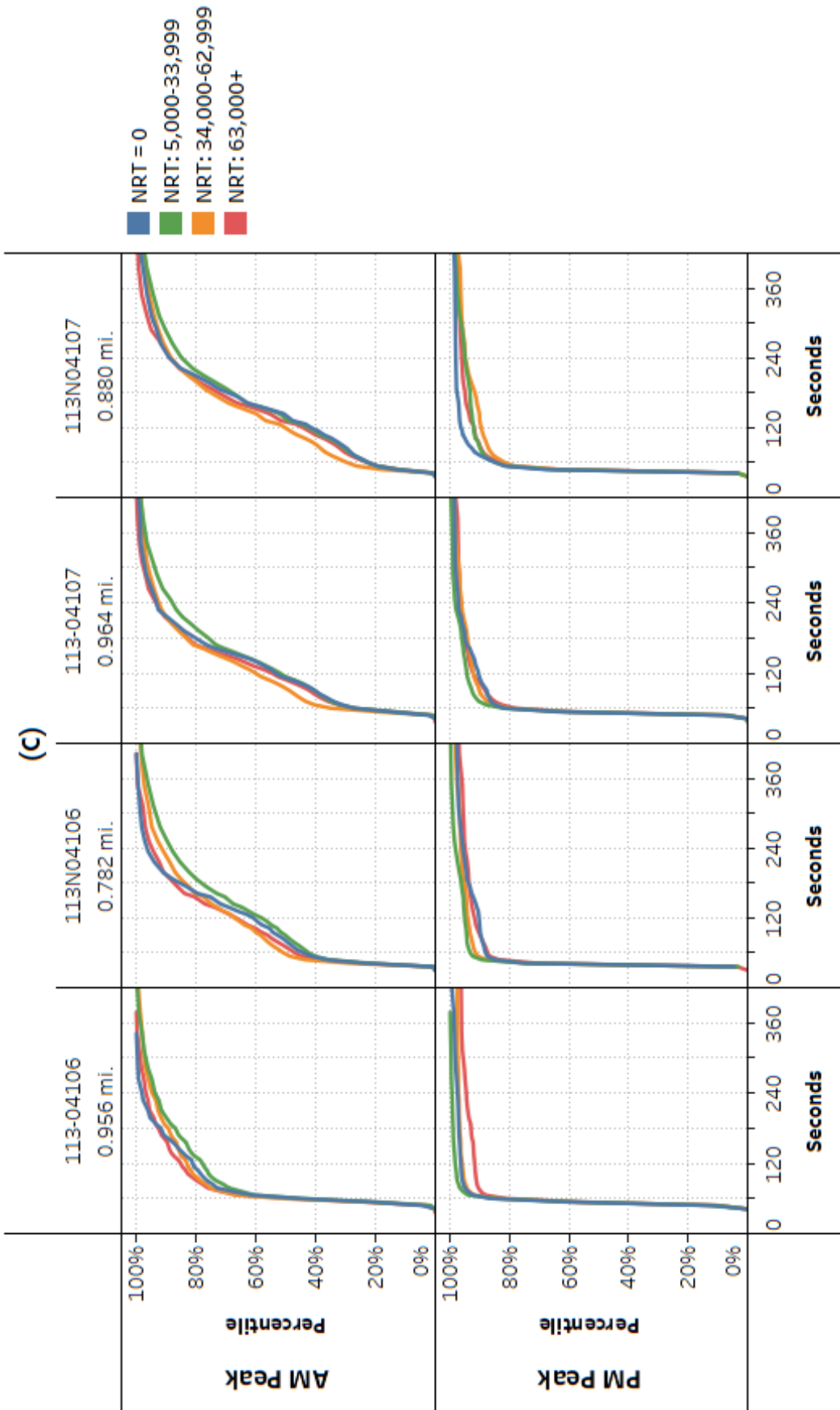


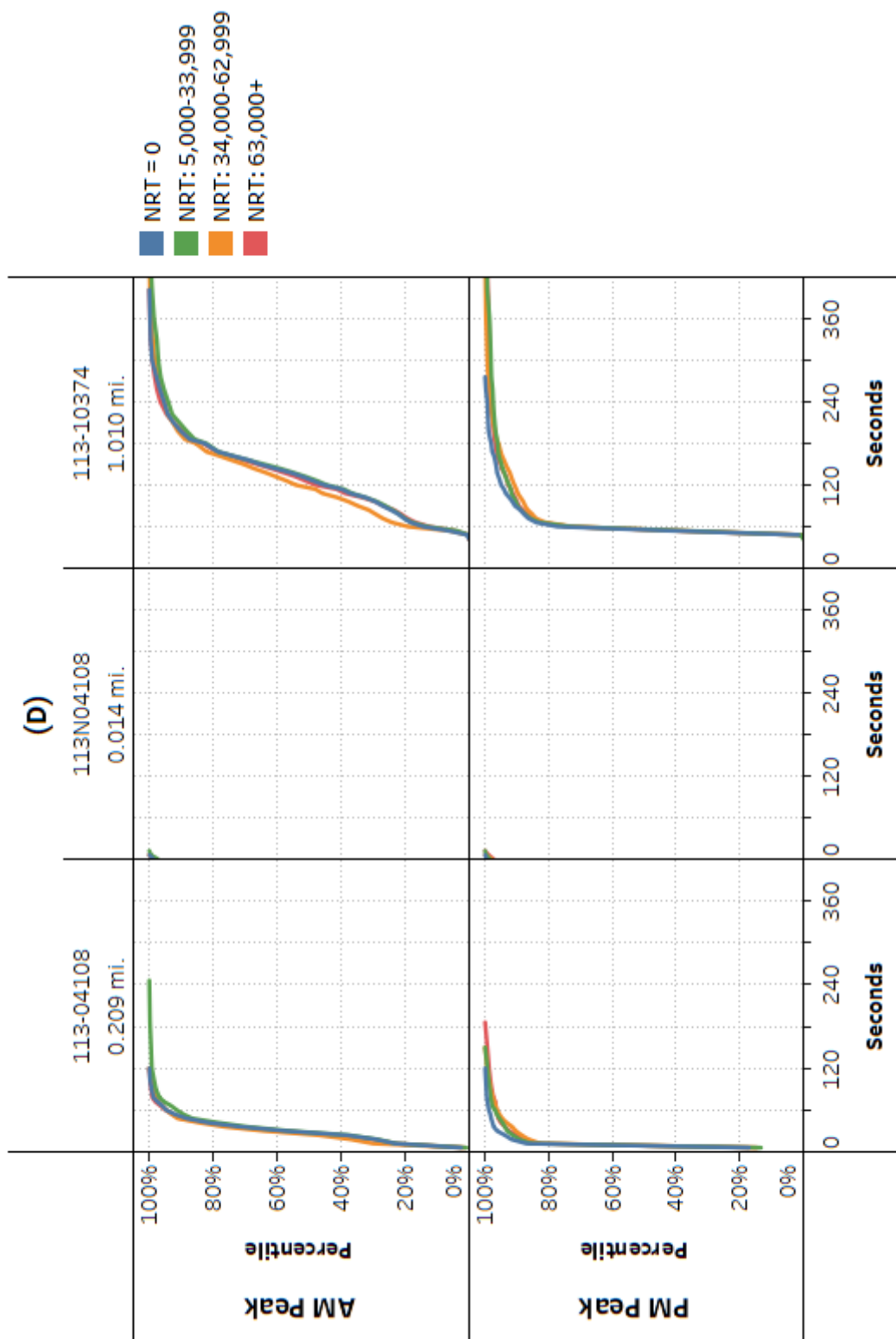


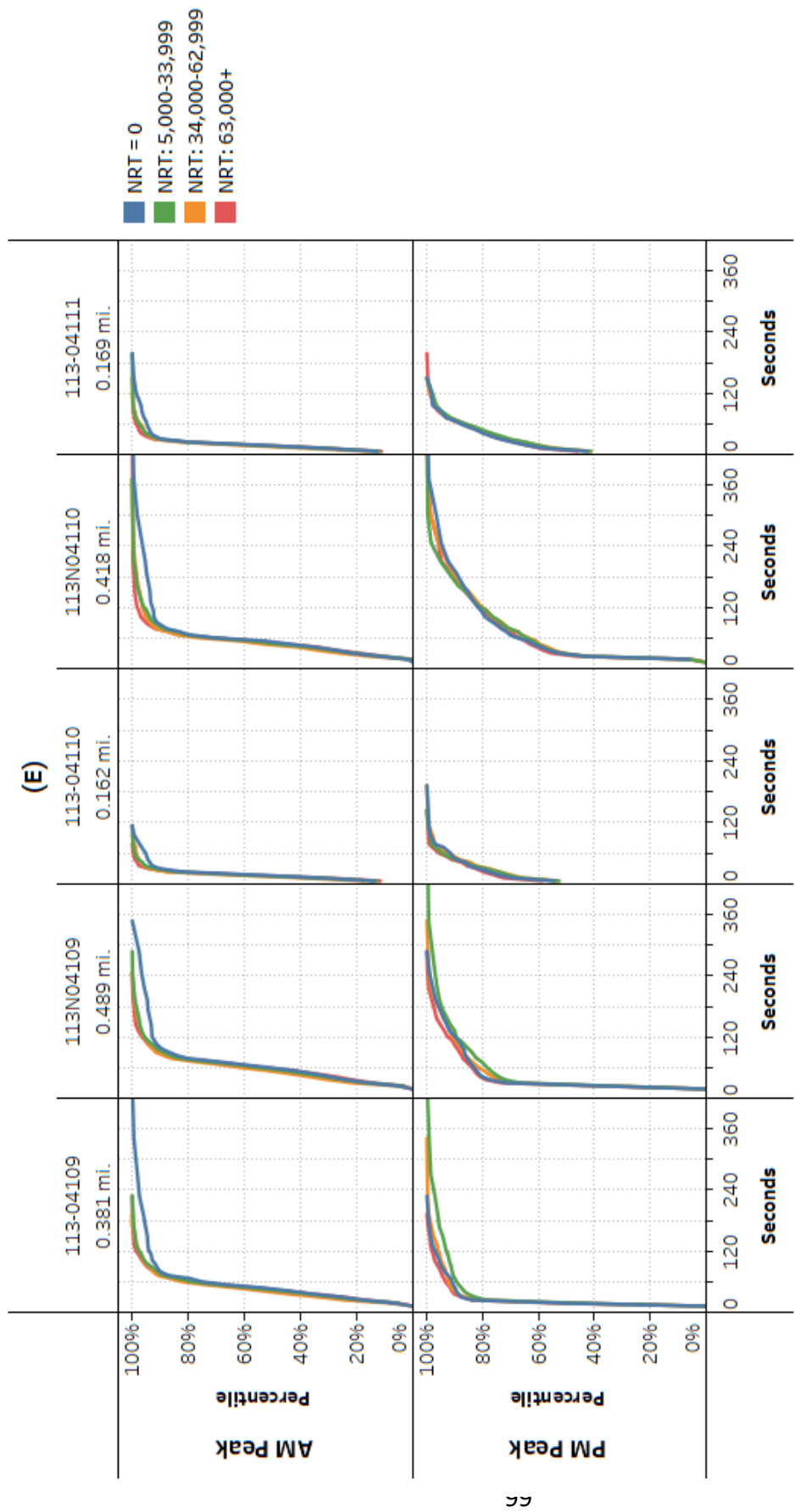
Appendix D. CDF plots Showing Impact of Container Vessel Size for Each TMC Segment Based on E&C Data

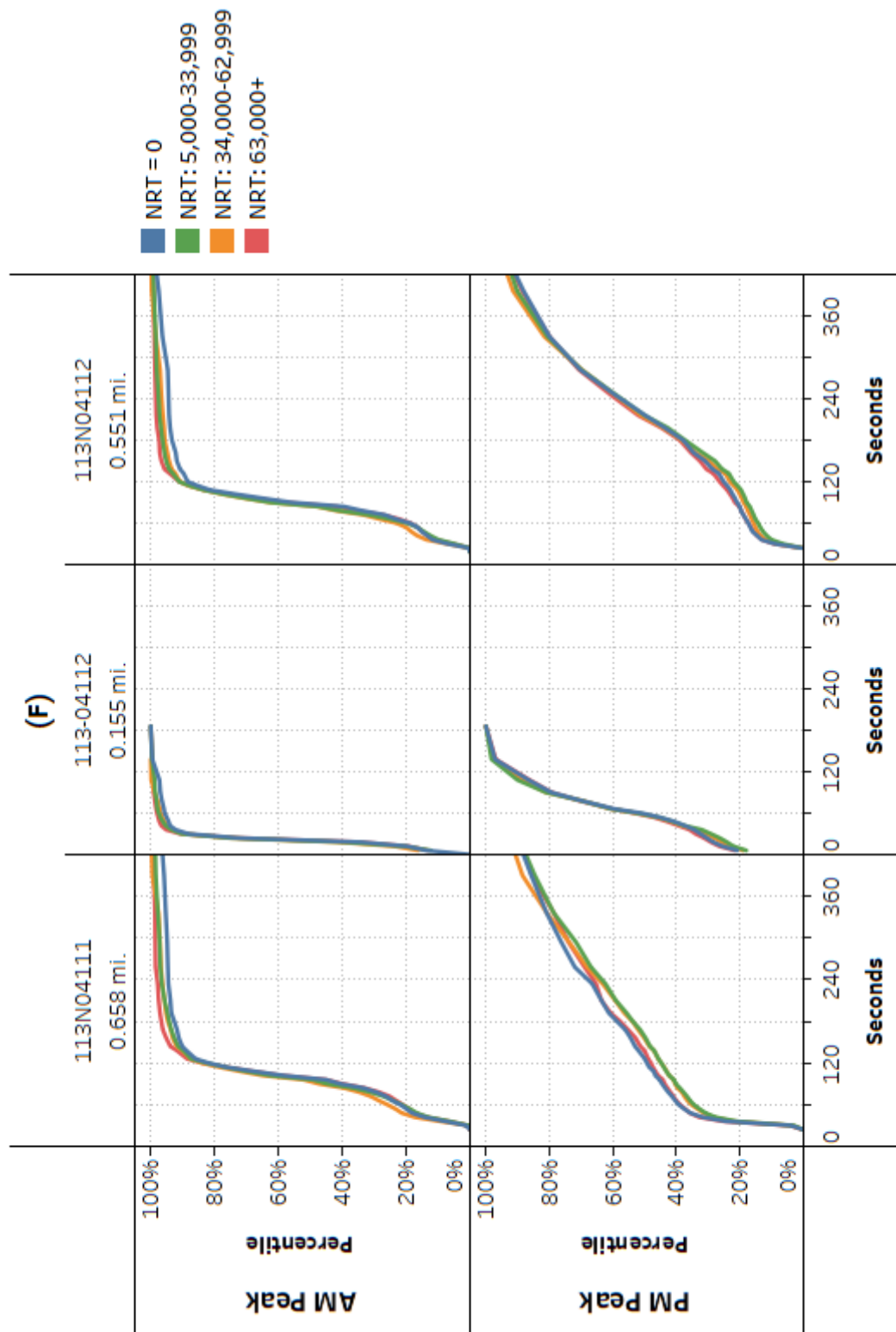












Vita

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